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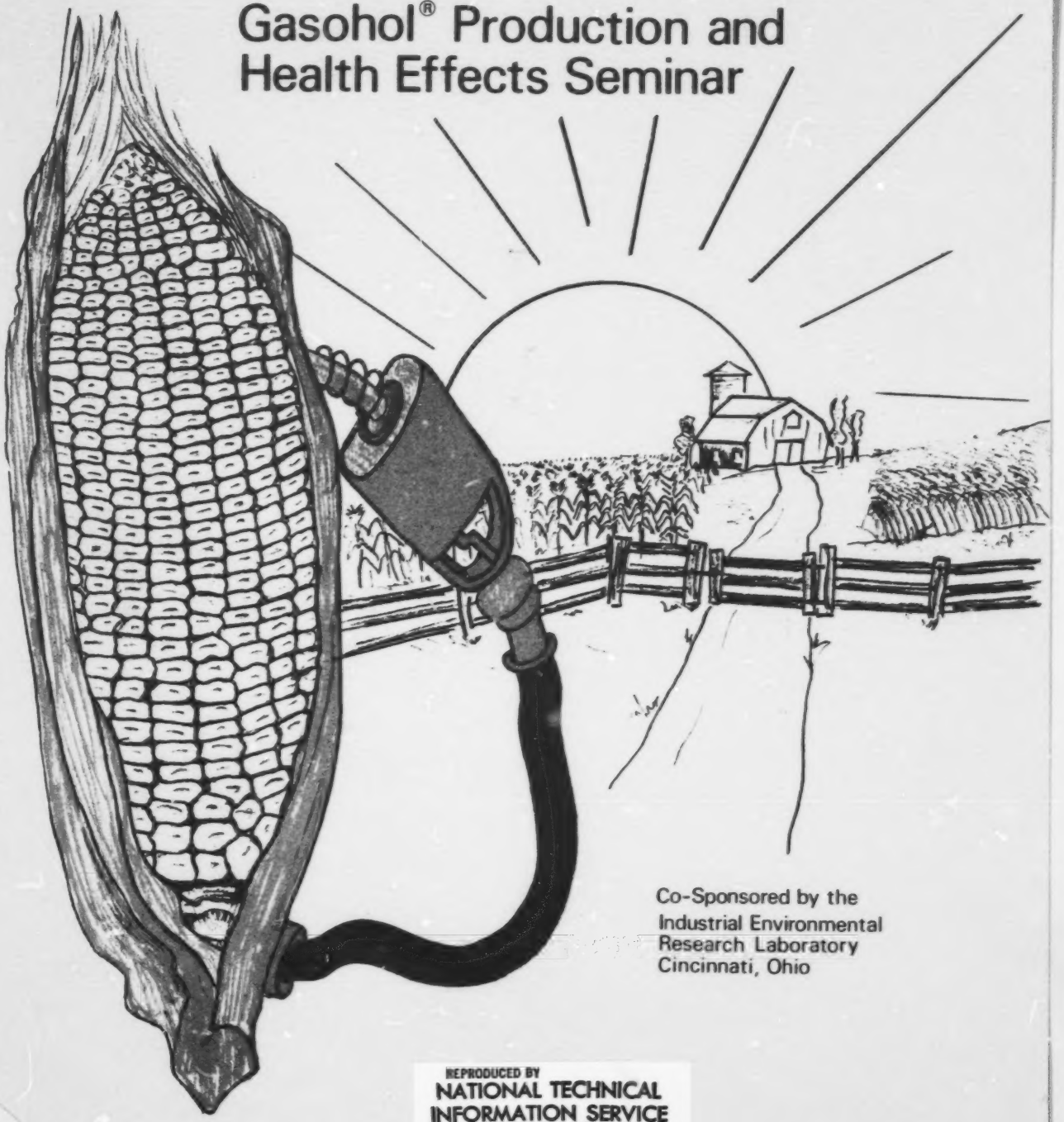

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This report presents the proceedings of the first EPA gasohol forum, held in Kansas City, Missouri on June 27, 1979. The presentations and discussions during the Seminar include on-the-farm energy, industrial alcohol production, Bureau of Alcohol, Tobacco and Firearms regulations, automobile exhaust emissions, and health effects.

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SEMINAR PROCEEDINGS
ENVIRONMENTAL EVALUATION OF "GASOHOL" PRODUCTION AND HEALTH EFFECTS

PROJECT OFFICERS
James W. Mandia
EPA Region VII, Kansas City, Missouri
and
Thomas J. Powers III
EPA Industrial Environmental
Research Laboratory, Cincinnati, Ohio

EPA Region VII Office
Kansas City, Missouri
June 27, 1979

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Charles J. Rogers, Physical Scientist, EPA Municipal Environmental Research Laboratory, Cincinnati, Ohio

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William A. Cawley

PREFACE

The U.S. Environmental Protection Agency, Region VII, is in the center of the grain production area of the the nation. It is only natural, therefore, that the farm movement to produce fuel from grain should originate here.

This seminar is a joint effort by Region VII and the Industrial Environmental Research Laboratory, Cincinnati, Ohio to bring together those groups actively engaged in programs to investigate the production of alcohol from grain and to initiate research to study its potential environmental effects.

This report presents the proceedings of the first EPA/gasohol forum. The presentations and discussions during the seminar were transcribed by a recorder and they, necessarily, required organization and editing.

Environmental Evaluation of
"Gasohol" Production and Health Effects
EPA Region VII, Kansas City, Missouri

AGENDA

June 27, 1979		Moderator
9:00 AM	Welcome & Objectives of Meeting	C. Hajinian W. Cawley EPA Region VII R&D &IERL, Cincinnati
	Alcohol Production	
9:15 AM	Industrial Processes	G. Ogle & R. Scarberry Radian
10:00 AM	Break	
10:15 AM	The Farm Energy Program	Dr. W. Scheller University of Nebraska
11:15 AM	Department of Treasury Regulations	T. George ATF Treasury Department
12:00 NOON	Lunch	
	Gasohol Fuel	
1:00 PM	Gasohol Combustion Research	R. Lawrence Ann Arbor, Michigan
1:45 PM	Potential Health Problems with Farm Energy	Dr. D. Coffin, EPA RTP, North Carolina
2:30 PM	Break	
2:45 PM	Energy and Economics of Gasohol Production	B. Mournighan, EPA IERL, Cincinnati
3:15 PM	Biomass to Alcohol Research	C. Rogers MERL, Cincinnati
3:45 PM	Summary	W. Cawley

ATTENDEES

Charles Hajinian
Environmental Protection Agency
Kansas City, Missouri

James Mandia
Environmental Protection Agency
Kansas City, Missouri

William Cawley
Environmental Protection Agency
Cincinnati, Ohio

Dr. William Scheller
University of Nebraska
Lincoln, Nebraska

Gilbert J. Ogle
Radian Corporation
McLean, Virginia

Dick Lawrence
Environmental Protection Agency
Ann Arbor, Michigan

Gordon Ortman
Environmental Protection Agency
Research Triangle Park, North Carolina

Jerry Allsup
Department of Energy
Bartlesville, Oklahoma

Donna Candler
Department of Energy
Kansas City, Missouri

Charles Rogers
Environmental Protection Agency
Cincinnati, Ohio

Clyde Dial
Environmental Protection Agency
Cincinnati, Ohio

Robert M. Scarberry
Radian Corporation
McLean, Virginia

Thomas Powers
Environmental Protection Agency
Cincinnati, Ohio

Thomas George
Bureau of Alcohol Tobacco & Firearms
Washington, D.C.

M.W. (Bill) Sheil
Department of Environment Control
Lincoln, Nebraska

Pamela Mintz
Environmental Protection Agency
Kansas City, Missouri

Ralph Summers
Environmental Protection Agency
Kansas City, Missouri

Ron Ritter
Environmental Protection Agency
Kansas City, Missouri

David Berg
Environmental Protection Agency
Washington D.C.

Ed Struzeski, Jr.
Environmental Protection Agency
Denver, Colorado

Bob Mournighan
Environmental Protection Agency
Cincinnati, Ohio

Dr. David Coffin
Environmental Protection Agency
Research Triangle Park, North Carolina

Todd Sneller
Nebraska Gasohol Commission
Lincoln, Nebraska

WELCOME AND OBJECTIVES

by
Charles Hajinian of R&D, Region VII
and
William A. Cawley, Deputy Director
IERL, Cincinnati, Ohio

Hi. I am Chuck Hajinian, Director of Research and Development, Region VII. I would like to welcome all of you to Kansas City to the EPA Gasohol Seminar sponsored by the Office of Research and Development, Region VII and the Industrial Environmental Research Laboratory, Cincinnati, Ohio. This was one seminar that Dr. Kathleen Camin, Regional Administrator, wanted to attend, but she is committed to be in New York this week. She sends her regrets and is in hopes this will be a productive meeting.

There probably is not a better time for a meeting such as this -- with the gasoline lines growing longer, and tempers growing shorter -- the interest in bio-fuels is growing at a dramatic rate.

Gasohol appears to have found acceptance in the marketplace and especially in the midwest. However, supplies are not yet abundant enough to meet potential demand. Because of the competitive nature of our system and the world's political problems, gasohol appears to be a potential fuel for future use in the internal combustion engine, especially on the farm.

This co-sponsored seminar is the first step toward evaluating the efforts and progress nationally and regionally of the gasohol and farm energy program and to obtain an overview of this program for an environmental evaluation.

I will now introduce Mr. William Cawley, IERL, Cincinnati.

Mr. Cawley: Thanks, Chuck. I will say only a few words and let you get to the meat of the meeting.

Speaking for the Laboratory and for the Office of Research and Development, we appreciate the opportunity to work with Region VII on this potential problem which is obviously a problem that is coming. I think everyone will agree that you only have to pick up the newspaper to learn of the need for alcohol to alleviate the gasoline situation. Production of alcohol for this purpose could cause environmental problems for which we should be prepared to do everything we can to solve. Depending on the shape it takes, we will determine whether we have a dispersed problem with everyone making alcohol in his backyard or as we hope, in the direction of a centralized industry.

Within the Industrial Environmental Research Laboratory, Mr. Clyde Dial is the Division Director responsible for most of the activities. Tom Powers and Bob Mournighan are the project level staff within the laboratory who have been assigned responsibility for the gasohol project and they are the staff members that you should contact for information.

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INDUSTRIAL PROCESSES

by
Gil Ogle and Robert Scarberry, Radian Corporation

Mr. Ogle: I look around and I see we are the only Government contractor here and I am a little bit surprised at that.

I would like to give a little background on Radian and our involvement with gasohol before I start. A year ago, someone in Cincinnati, I am not sure who, but Tom Powers was involved, saw that gasohol might be something. At that time, gasohol was a nebulous thing and the only people active in gasohol were in Nebraska. But IERL asked us to take a look at what environmental impacts would be if a gasohol industry, or rather, an alcohol industry, were developed to support the projections of large-scale gasohol use. As many of you are aware, there were and still are a lot of politics involved. Some of the concerns regarding gasohol were unfounded; other concerns were exaggerated while many of them are still being investigated.

Over the past year, we have visited a number of alcohol facilities and written two or three reports regarding alcohol processes as well as the environmental control options and regulations that will impact a fuel alcohol industry.

Alcohol production from biomass for fuel use is growing now and it is difficult to keep up with it, as I am sure most of us here have found in trying to stay up on all the changes and processes.

Our presentation is based on the standard fermentation process. We will, however, talk about the options and modifications that are coming along, and people like Bill Scheller can add to it, I am sure.

Bob Scarberry is going to present the part on alcohol production because he is the one who has been doing the engineering part of it. Then I will try to cover the regulations and control technology. So with that, I will let Bob go ahead.

Mr. Scarberry: You should have two handouts in front of you for our part in this presentation. The first talk, which I will give, is entitled "Industrial Ethanol Production" and the second, which Gil Ogle will give, is entitled "Environmental Regulations and Control Technology for Ethanol Production." There are copies in the handouts of the slides we are going to show.

The first slide (Figure B-1) is a general flow diagram for an alcohol process. It is divided into six different units and is representative of most existing plants. This scheme is for grain alcohol, but can be used for other sources of biomass, such as sugar crops. When cellulosic conversion processes become economical, wood products, agricultural residues, and municipal solid wastes will be candidate feedstock for the fermentation process.

The first section is grain preparation. This is followed by saccharification, a biological process where enzymes break down the carbohydrates into sugars. Next is fermentation (another biological step) where yeast convert the sugars to ethanol and CO_2. The next step, distillation, separates the water from the alcohol. The final step is by-product processing, which in most cases produces distiller's dry grains, or DDG.

In a fuel alcohol process, a dehydration unit is used to make 100 percent alcohol. In a conventional ethanol plant designed for beverage production, this dehydration unit does not exist; instead there are a series of purification columns which yield a closely specified product. Most often 190-proof neutral spirits are produced for blending stock. Let us examine each one of these units separately in a little more detail.

When the distiller gets the grain, his first job is to grind the grain. This is achieved by either dry milling with hammer mills or by wet milling processes, which also remove some protein and fiber from the grain. The milled grain is then slurried with water to facilitate handling for downstream processing.

The second step is saccharification, or cooking. (Figure B-2.) In this step the mash is heated up to about 300 degrees (by direct steam injection) to solubilize the starches. It is then cooled and converted in an enzymatic hydrolysis process where the long sugar molecules are broken into component five and six carbon sugars. Before the mash is sent to fermentation, it has to be cooled to about 80 degrees Fahrenheit to promote yeast activity.

The next step is fermentation, where sugars are converted by the metabolic processes of yeast. Ethyl alcohol and carbon dioxide are the chief products. Temperature, pH, and nutrient level in this unit are very important. The residence time for a batch fermentation process is two to three days, resulting in a product stream that ranges from 10 to 12 percent alcohol. There is also about six to eight percent solids in this stream; the solids are mostly fibers and dead yeast cells along with some protein and oils which may not have been removed prior to fermentation.

In distillation (Figure B-3), solids are removed and the alcohol is concentrated to about 95 percent. Also, some of the impurities, which include higher alcohols (fusel oils) and aldehydes, are removed. Live steam is shown here as the heat source, indicating that this is quite common in conventional distilleries. In a modern fuel facility, a reboiler can be used to cut down on the energy requirements. The feed to the rectifier is routed from the first column, called the beer still, at a concentration of about 80 percent ethanol, 19 percent water, and one percent impurities.

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The fusel oils have higher boiling points than the ethanol/water overhead stream. Therefore, these fusel oils will condense before they reach the top of the column. To avoid the accumulation of fusel oils in the rectifier, side streams are taken off the rectifier.

At atmospheric pressure it is impossible to remove the last five percent of water from the distillation column without using some other type of system. A dehydrating agent can be added to the mixture in another set of columns to remove by azeotropic distillation the remaining five percent of water (Figure B-4). The most common dehydrating agent used today is benzene, although there are other compounds such as hexane, cyclohexane, ethyl ether, and gasoline.

With the correct feed composition and proper conditions of temperature and pressure in the column, the properties of the system permit withdrawl of anhydrous or water-free ethanol from the bottom of the column. The column overheads contain all three components -- benzene, ethanol, and water. This stream is routed to the separator where two layers are formed: A benzene/alcohol rich layer and a water/ethanol rich layer. The top layer is recycled to the dehydration column, while the bottom layer is sent to a recovery column. In the recovery column, benzene and ethanol are taken off the top of the column and recycled back to the dehydration column; bottoms, consisting of mostly water, are withdrawn for further treatment.

By-product processing (Figure B-5) is very important to the economics of a distillery. Because a very high strength waste stream is involved, sending it to wastewater treatment would be very expensive. Most plants have found it profitable to convert this stream into a useful by-product. Typically, water is removed from the waste stream using centrifugation, evaporation and drying. The resulting by-product is a high protein animal feed supplement. This operation unfortunately consumes large amounts of energy.

This is a drawing (Figure B-5) of the by-product processing, indicating that prior to the centrifuge, the solids are passed through a screen to remove fibers or large solids. Part of the thin liquids, which are about one to three percent solids, are recycled to the cooker or fermenter; the remainder are sent to an evaporator. This stream is concentrated in the evaporator to 35-50 percent solids and then routed to the dryer.

In the dryer, most of the remaining moisture is removed. The final product contains about 92 percent solids. If a direct contact dryer is used, there will be a high concentration of particulates in the effluent stream. A cyclone or wet scrubber is usually employed to remove these particulates from the air stream before it is vented to the atmosphere.

One innovation in alcohol production is the use of gasoline as a dehydration and denaturing agent. Vacuum fermentation is another important breakthrough although it is currently in the experimental stage.

Anaerobic digestion is an alternative to DDG production. In this process, the stillage from the beer still is sent to anaerobic digesters. Methane is the primary product and can be used for heating; one plant claims that methane provides 60 percent of its energy requirements. A digested sludge is also produced from anaerobic digestion and can be used as fertilizer or disposal of in a landfill.

Thermophilic yeast are organisms which can survive at higher temperatures. There are two ways that these are useful; one is in vacuum fermentation. If you have an organism which can convert sugars into alcohol at higher temperatures, you need less vacuum on that system. This can save substantial amounts of energy. Since the fermentation reaction produces heat, using yeast that can survive at a higher temperature would mean lower cooling requirements and hence yield another energy savings. Genetic research is also being conducted to develop higher crop yields.

I would like to give a little more detail on the first three processes. This slide (Figure B-6) shows denaturing and dehydration with gasoline. This varies from the other denaturing example in that the denaturing agent is not recycled. Gasoline is added in the dehydration column and it leaves the bottom of the column with the alcohol. Additional gasoline is added to achieve a 90 percent gasoline, 10 percent alcohol mixture which is gasohol. The water is taken off the top of the dehydration column and routed to a separator. The water is taken from the separator and recycled back through the distillation train and finally leaves the system via the beer still bottoms. One obstacle to be overcome is ATF approval of gasoline as the sole denaturing agent in a completely denatured formula.

Continuous fermentation (Figure B-7) permits the use of a much shorter residence time and results in lower alcohol concentration than conventional batch fermentation. The yeast are kept alive and centrifuged out of the product stream. Most of the yeasts are recycled, but some of this material sent to by-product processing as a blowdown stream to reduce the buildup of contaminants and dead yeast cells. The yeast stream is aerated and supplied with nutrients for the organisms prior to return to the fermenter. Also, fresh makeup yeast are continually added to the fermenter.

Continuous fermentation conducted under a vacuum is called vacuum fermentation (Figure B-8) In this process, the alcohol is evaporated overhead by a vacuum jet as it is formed. It is very important to keep the alcohol concentration less than about six or eight percent because higher amount of alcohol are toxic to the yeast, thus preventing effective yeast recycle.

Mr. Ortman: President Carter announced a couple of days ago that he was proposing investing millions of dollars in solar energy and he identified one area of the investment, solar energy, for development of gasoho

processes. Where do you see the use of solar energy in your processes which you described?

Mr. Scarberry: Well, solar energy currently is being applied to the distillation section to evaporate the water from the ethanol/water mixture. One man that is using a solar still gets only about 140-proof (70 percent) alcohol, so you need to come up with a type of system to remove the remaining water.

Dr. Coffin: Would it be useful to use solar heat in the evaporation of the by-product for animal feed?

Mr. Scarberry: Yes, to remove some of the water. One of the problems with applying solar energy is that you can only get so much heat -- maybe 200, 220 degrees.

Dr. Coffin: With common technology?

Mr. Scarberry: Right. So if you processed under vacuum you could use solar energy but you would need another source of energy to supply that vacuum which may be another good area for solar energy application.

Mr. George: You made a statement that ATF would not approve gasoline as a denaturing agent. Aren't we going to change our formulas?

Mr. Scarberry: I meant to say that right now gasoline alone is not a legal way to denature ethanol.

Mr. George: Right now I think it is a combination of MIBK, gasoline and alcohol, and we are going to remove the MIBK as part of the formula and use gasoline to completely denature the alcohol. I just don't want the people to leave here thinking that we are going to leave the formula as it is.

Mr. Scarberry: Okay, I don't want to get into that. I thought you would be talking about it here. Yes, ATF is working on it right now. As a matter of fact, there is one distiller in the Washington, D.C. area that plans to use this system next March. I don't know if they have talked to you at all about this.

Mr. George: It is just a matter of changing the formula.

Mr. Scarberry: Right.

Mr. Lawrence: A publication I have by DOE indicates that Formula 28A does allow a gallon of gasoline.

Mr. George: Well, that is a special denaturing formula.

Mr. Lawrence: Yes.

Mr. George: A special formula is much more restrictive than a completely denatured formula. Completely denatured alcohol, you can do anything you want; specially denatured, you can't. That is the rub.

Mr. Lawrence: But this one says: "For gasoline, for uses motor fuel."

Mr. George: Right, but the restrictions on it would really be a pain.

Mr. Lawrence: Okay. I am a little concerned about MIBK.

Mr. Scarberry: That can only be sold to certain people who are permitted to buy it. There are a lot of restrictions.

Mr. Lawrence: MIBK has some problems of its own; it is not very compatible with filtering materials and so I guess the waiver, when it was approved for gasohol use, intended to denature ethanol for blending gasoline.

Mr. Scarberry: It is also very expensive.

Mr. Lawrence: It would be nice if gasoline could be used. Will gasoline eventually be approved?

Mr. George: Yes, that is what I was saying, there are changes in CDA 19. It could be a combination of gasoline and alcohol and with the MIBK left out.

Mr. Lawrence: Okay. Thank you.

Dr. Scheller: Yes, I was just going to comment that our Nebraska two-million mile road test program where we purchased anhydrous ethanol from Georgia Pacific Corporation in Washington where Co-op Refiner's Association did the blending of the alcohol and gasoline for us, everybody had the appropriate permits and bonds so that we were able to use 28-A as the special denaturing formula; and by the time it was blended with gasoline at the 10 percent level to produce gasohol, ATF didn't seem concerned about the alcohol not being completely denatured. So to the best of my knowledge, other than possibly small runs or laboratory runs, such as Jerry Allsup is doing down at Bartlesville, our two-million mile road test was the only one that did not have denaturants in the alcohol such as we find today in commercial gasohol.

Dr. Coffin: I want to ask you a question concerning the benzene. You mentioned benzene as being a dehydrating agent. Is there some residual benzene left in the gasoline?

Mr. Scarberry: There is benzene in gasoline anyway -- quite a bit of it. In the sampling and analytical program that Radian is conducting, we hope to identify the levels of benzene in the alcohol as well as in other streams. We also want to screen for pesticides to determine the fate of these compounds in an alcohol plant. But, benzene right now is probably the most common dehydration agent. It is used now almost exclusively in Brazil in their alcohol fuels program and there are a couple of companies in the United States using it. A lot of people are thinking about using alternative dehydrating agents because of all of the environmental problems associated with benzene.

Dr. Scheller: Here, again, I might add that it is a simple matter to simply replace benzene with cyclohexane in the existing equipment.

Mr. Rogers: I would like to make a comment and ask a question. You made some reference to the effects of pesticides on fermentation operations. Currently we are looking at supporting research to determine how to treat seed corn to remove the pesticides. This program has shown that a certain pesticide can be destroyed through the fermentation process, for instance captan. I understand there are millions of bushels of seed grain that must be disposed of annually, and fermentation may become a pesticide disposal process.

The question is, have you considered the use of detreated grain for alcohol production and determined the operating requirements for using such grain for fermentation?

Mr. Scarberry: We haven't made any fermentation studies using detreated grain, but we are investigating alternative alcohol processes.

We haven't done any economic studies on any of the process units. Most of the studies I have read by other people show that the newer processes have positive energy balances (i.e. use less energy to produce alcohol than results from burning it) by using energy conserving measures like use of column reboilers rather than live steam. In the distillation and dehydration system, the object is to get rid of water and when you inject water into the column tc remove water it is not very energy-efficient. The reason they do it now in beverage alcohol production is for purification purposes. They dilute the alcohol vapor stream down with large quantities of water to remove contaminants.

Mr. Allsup: I am concerned about using gasoline as a denaturant for alcohol without using some other denaturant along with it.

Mr. George: Yes, that's the rub. You mean it would be easy to take gasoline out of the alcohol?

Mr. Allsup: Yes, unless there is some other component to prevent this.

Mr. George: I think what we will come out with is some percentage of gasoline ratio to alcohol. I don't know what it is right now. We are working on it. We are trying to get that to CDA, and completely denatured alcohol formula 19 changed so that it would just be a mixture of gasoline and alcohol. I think it is a small amount of gasoline. I am not exactly sure of the ratio.

Mr. Lawrence: Formula 19 specifies a gallon of gasoline to 100 gallons of ethyl alcohol.

Mr. George: No, that is formula 18. If I remember correctly, formula 19 is five gallons of gasoline to every 100 gallons of alcohol. Something like that. But it will be a specific ratio.

Mr. Allsup: The composition of the gasoline will not be specified.

Mr. Scarberry: Hopefully, the blenders might want to use a lower octane gasoline so that when they add the alcohol the gasohol blend will have the same number octane as regular gasoline.

Dr. Scheller: If I can inject my opinion, hopefully the alcohol producers will use a gasoline as a denaturant that can be purchased at the bulk station so that there is always a ready supply of denaturant.

Mr. Scarberry: That is one problem that hasn't really been addressed or identified yet. Who will do the mixing? That is one problem that a lot of people haven't faced; whether it should be done at the alcohol plant or the refinery. One man from Brazil said that blending in their country consists of the jobber loading it in the tank trucks and making a lot of quick starts and stops.

Dr. Scheller: Another point that we could probably make on that formulation is that the gasoline specified should be unleaded, not leaded.

Mr. Mournighan: How far do you have to go in the dehydration steps and is it necessary to go to 100 percent alcohol? How much water can be tolerated in the alcohol?

Mr. Scarberry: Using a dehydration process to remove all of the water is not necessary. Several researchers are conducting experimentation with blending agents to help keep ethanol blended with gasoline in the presence of water. I don't think these chemicals are commercially available yet.

Mr. Mournighan: Without the blending additives, how much water can be present in gasohol at summertime temperatures?

Dr. Scheller: Yes, the amount of water that can be present in gasohol is a function of temperature, of course, but 190-proof ethanol, for example, is five percent water, which means in a gasohol mixture you have a half percent water and the cloud point of this mixture is somewhere down around 30 degrees Fahrenheit, so in the summer it can be used without difficulty. In Thailand, for example, they are running tests, road tests, exclusively with 190-proof. Now, Thailand does not have winter of course. In a number of Carribean countries, sorgum is used to make alcohol, and alcohol is required in gasoline by legislation because of low world molasses prices. I think in this country experiencing winter conditions, anhydrous ethanol or nearly anhydrous ethanol is necessary of make gasohol in order to insure customer satisfaction. If 190-proof is used, phase separation can occur in the fuel lines. I think that we would be making a big mistake if we agreed to 190-proof ethanol, because I think it would be a higher percentage water than is acceptable for customer satisfaction.

The amount of money which reflects the energy capital cost, that is, the cost of converting the 190-proof to 200-proof is about three cents per gallon of alcohol. Now, don't get trapped in seeing the 10 percent differential in price between 190-proof and 200-proof ethanol

because 190 is only 95 percent alcohol. You would have to divide the quoted price for 190 proof by .95 to get the cost of a gallon of 200-proof alcohol.

Mr. Lawrence: What does 190-proof sell for at the present time?

Dr. Scheller: Ten cents less than 200-proof per gallon. This small difference between 190-proof alcohol and the 200-proof alcohol is not worth the risk of the potential problems associated with phase separation.

Mr. Mournighan: Do you think the higher alcohols present in the alcohols used for blending will serve to reduce phase separation?

Dr. Scheller: Yes, but they are present in a relatively low concentration in fuel grade ethanol, less than one percent. So they are less than a tenth of a percent in the gasohol mixture. I don't think you can count on this being significant. It may help to lower the temperature of phase separation a few degrees. It is not going to solve the problem.

Mr. Ogle: I am going to discuss the environmental regulations and the control technology that will apply.

First, I will start with the major sources of emissions from an alcohol plant. As far as air emissions are concerned, the major sources are a coal-fired boiler, condenser vents on distillation columns, and exhaust from the direct contact dryers. A lot of plants don't use coal-fired boilers, but it is a worst case evaluation as far as air emissions go.

The major source of wastewater volume-wise is the cooling tower blowdown. On a pollution basis, the more important waste streams include the evaporator condensate (which might be sent to the cooling towers,) equipment washes, and scrubber blowdown. The wastewater is high in BOD and suspended and disolved solids.

Sources of solid waste are fly ash from the coal-fired boiler and bio-sludge if the plant has its own wastewater treatment facilities. The sludge from bio-treatment can be recycled to by-product processing for inclusion into the distiller's dried grains.

Federal regulations on particulates, SO_2 and NO_x only apply to sources greater than 250,000,000 BTU's per hour. A typical plant for alcohol production, assuming a 20 million gallon per year plant, is going to have a boiler about half that size or less. There are Federal opacity standards for dryers, grain elevators, truck or railcar loading and unloading and other grain handling operations which might apply. We have examined the regulations for all four states in Region VII.

Very strict regulations exist for SO_2, and flue gas desulfurization is very expensive. Low-sulfur coal, natural gas, or low sulfur fuel oil can be used to avoid FGD and meet compliance requirements NO_x regulations really are not applicable to this size facility.

All states have standards for particulates from incinerators, dryers, and steam generating equipment. In addition, Illinois and Iowa have particulate emissions standards for grain handling and drying.

The particulate control options that we have looked at include inertial separators, such as cyclones and mechanical separators; electrostatic precipitators; wet scrubbers; and fabric filters (bag houses).

Electrostatic precipitators are a little questionable because of the hazard that might result in handling grain dust and coal dust. Normally, ESP's are used for fly ash, they might be used on the boiler, but probably not on a dryer.

Wet scrubbers and fabric filters are the most common; with wet scrubbers there is liquid waste stream which must be treated. The collected grain or coal dust can be recovered from fabric filters, thus eliminating a solid waste problem.

There are no federal water regulations specific for alcohol production. There are standards that may apply to other processes like sugar mills and grain mills which will require secondary treatment. General water quality standards do exist which must be maintained. These parameters are BOD and suspended solids. The most stringent regulations are found at the state and local level. There are specific levels on pH, organic materials, and other pollutants that cannot be put into a publicly owned treatment works (POTW). All may be required to meet a standard on the Waste Liability Section. That would be especially true in the case of benzene, pesticides, and certain solid wastes. The Resource Conservation Recovery Act (RCRA) is still evolving, but there are parts of RCRA that may apply. In general, these facilities will not generate a hazardous waste which is going to cause any problem that is if any solid waste is generated at all.

The criteria we use for selecting pollutant control equipment includes development status, applicability, performance, capital and operating cost, and secondary pollutants.

The impurities can be removed from the fermenter vent stream and the carbon dioxide can be recovered. Hydrocarbons do not exist in sufficient concentrations to make their recovery economical.

NO_x control options include combustion modifications such as staged combustion, flue gas recirculation, and low excess air firing.

The lime/limestone throwaway process is the most likely choice for flue gas desulfurization to control SO_2 emissions. Other less common options include sodium carbonate throwaway, sodium/lime alkali, magnesia slurry, and Wellman-Lord.

The control options for hydrocarbons include adsorption, compression-condensation, absorption,

and direct flame and catalytic incineration.

To control fugitive hydrocarbons, a systematic preventative maintenance program is essential; floating roofs or internal floating covers can be used to reduce these emissions.

Wastewater treatment control options are screening, sedimentation, air flotation, flocculation, aerated lagoons, trickling filters, anaerobic digestors, and activated sludge units. All of these options are currently being employed at alcohol wastewater treatment plants to reduce BOD and suspended solids.

As one alcohol plant currently shows, it is possible to recycle or reuse all the solid waste generated in a typical alcohol plant. All organic matter can be included in the by-product grains which is sold as feed, or used as fertilizer (Figure B-9).

Other solid waste treatment and disposal options are to dry the by-product waste on beds, use it for landfill, or landfarm it.

In general, I would like to say something about the emissions control options. We have looked at this extensively over the last year and we don't find anything that we would call a serious or an insurmountable problem. We look at it more from the engineering, energy and conservation side, however, there are a lot of things that could be pollutants or perhaps by-products. Since most of the plants that will provide alcohol for gasohol production will be grass roots plants, every effort should be made to recover everything possible from them.

I don't believe there will be pollutants that cannot be controlled using proper engineering design and operation.

Mr. Dial: Your basic presentation was built around what size of facility?

Mr. Ogle: Twenty million gallons per year.

Mr. Dial: Have you looked at the implications from a control standpoint for all the little, what I call "mini-plants" that may crop up or are cropping up?

Mr. Ogle: No. I knew that question was going to arise. That was not part of the charter of this program but we have looked at it informally, as everyone has. It will be interesting, I am sure there will be some different problems arising. Probably on the small on-farm unit stillage will not be dried.

Stillage will be fed wet and that presents a new problem. I have heard that the urine output from cattle fed wet grain supposedly increases substantially. It creates a totally new problem. You know as well as I do that farmers are not diligent in collecting animal wastes. I can cite an example. At the University of Maryland dairy experimental station, operators have not been collecting animal waste over the years that the facility has been in operation. Pollution is starting to showup in the valley below the farms as a result of years of accumulation of cattle waste and runoff. They have not even gone so far as to put down a well to check the groundwater. Pollution is visible in the surface waters. So that is the type of thing that is apparently going to happen with the operation of a small farm alcohol plant. It is probably not a problem that will be seen in the first five years.

Mr. Dial: I may have missed it, but I believe in your last slide you were showing options for solid waste disposal and it looked like there was no process waste in the production of alcohol. Did you cover that before?

Mr. Ogle: There really isn't any process waste. Everything goes either through the by-product or ends up in the wastewater sludge. It depends on the front end process, how grain is fed. There may be some grain dust and grain materials as a solid waste; however, this can be added to the DDG. But, there really isn't a process waste.

Mr. Dial: Is that characteristic just of a large facility or is it also characteristic of a small facility?

Dr. Scheller: I think I am going to talk about the small facility next, and that subject will be discussed.

Mr. Berg: You believe that pollution is not a major problem with the industrial alcohol plant. What percent of the total cost of one of these plants is going to be charged to pollution control?

Mr. Ogle: I don't know. There are alcohol plants operating now in Region VII that could probably give you some data.

Dr. Scheller: I was just going to say that question is difficult to answer because there has only been one new alcohol plant built in recent years and that one is a Decatur, Illinois. This plant is part of a corn sweetner project, so it may be hard to separate the pollution control aspects, the alcohol production, and the corn sweetner production.

Mr. Ogle: It looks like their waste treatment system, water, air, everything is all tied together with the corn sweetner operation and there is no way that the different systems can be separated.

Dr. Scheller: In the initial design and operation, water treatment was part of the alcohol plant.

Mr. Ogle: Yes, that is right. The newest plant, in fact, in North America is in Canada. We visited that plant and they have a waste problem.

Dr. Scheller: Are you referring to the one in British Columbia?

Mr. Ogle: Yes. The plant is in a very pristine area which has strict environmental requirements. The plant land farms their biosludge waste. Down stream from the land farm, bore holes are drilled and their wells are teste

periodically. The water is starting to show trace elements downstream from the land farm.

Mr. Berg: What trace elements?

Mr. Ogle: I don't know. Maybe trace element is the wrong term there.

Mr. Scarberry: Salts.

Mr. Ogle: They know that salts are coming from their sludges and they freely admitted that to us.

Mr. Ogle: One of the things we would like to do is sample a facility that land farms their waste and perform a screening analysis to find out if we can determine the fate of pesticides and fungicides if they are still there. I have a feeling that pesticides are probably destroyed in the fermentation process. Most people who work with grain fermentation feel that way, but it hasn't really been adequately demonstrated.

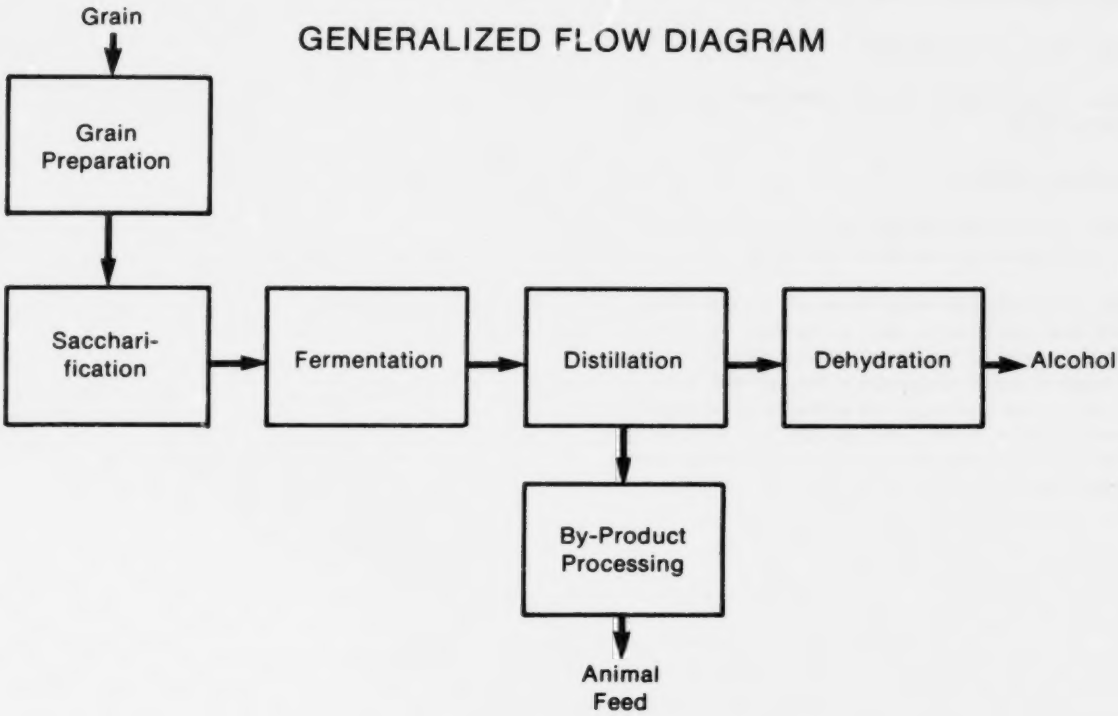

Figure B-1

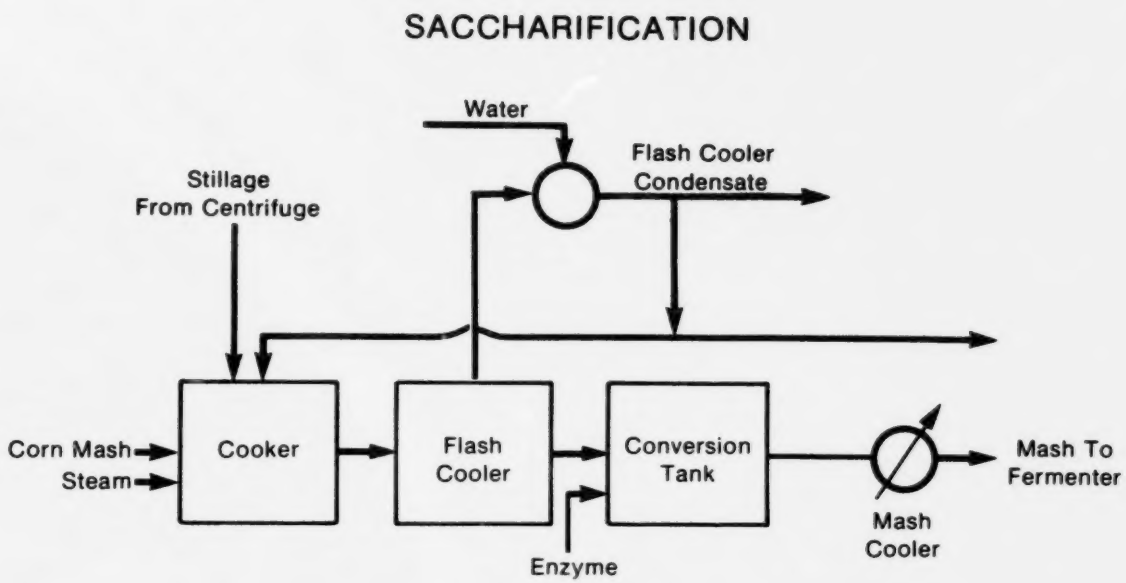

Figure B-2

DISTILLATION SEQUENCE

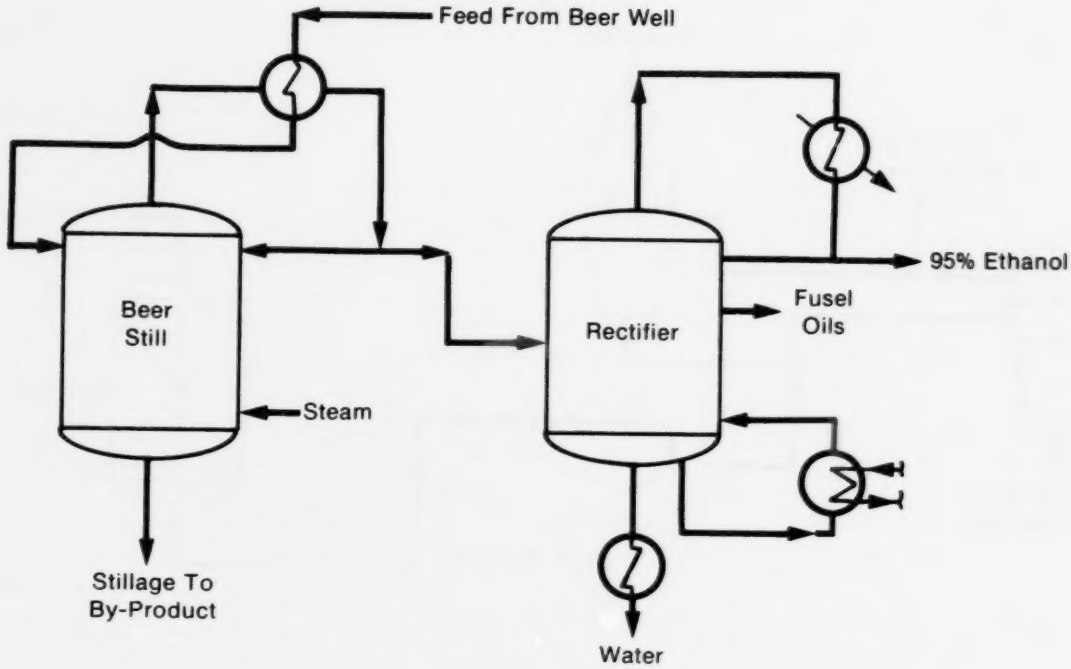

Figure B-3

TYPICAL DEHYDRATION SEQUENCE

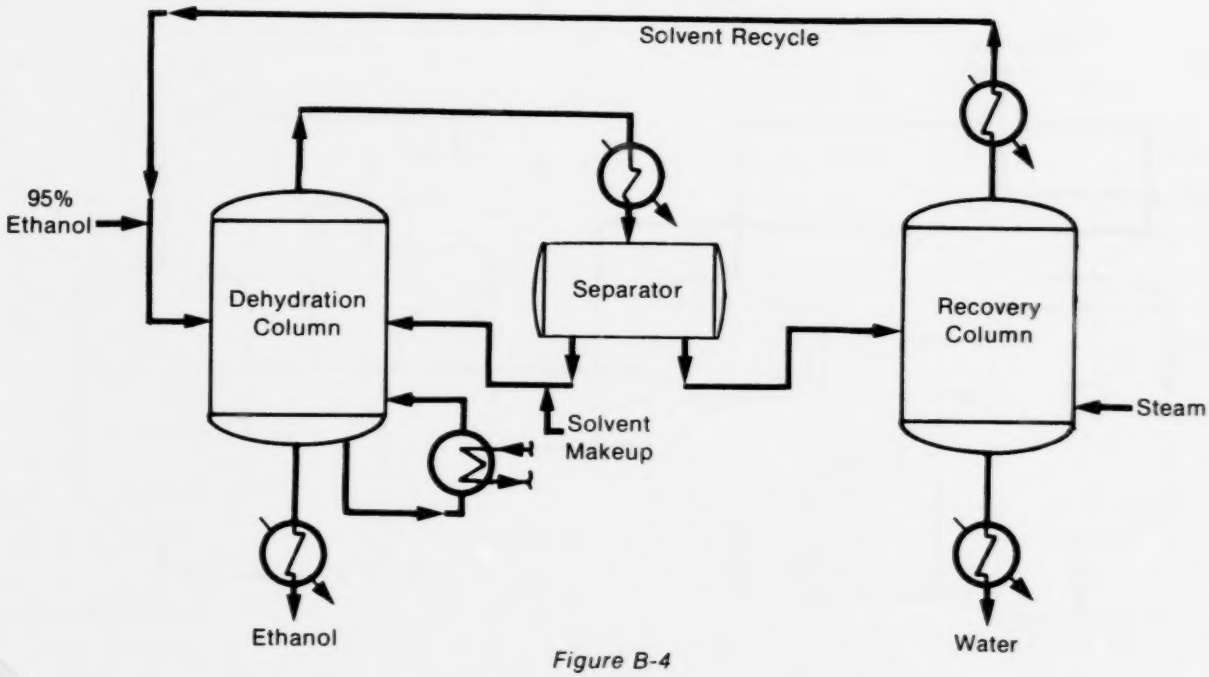

Figure B-4

BY-PRODUCT PROCESSING

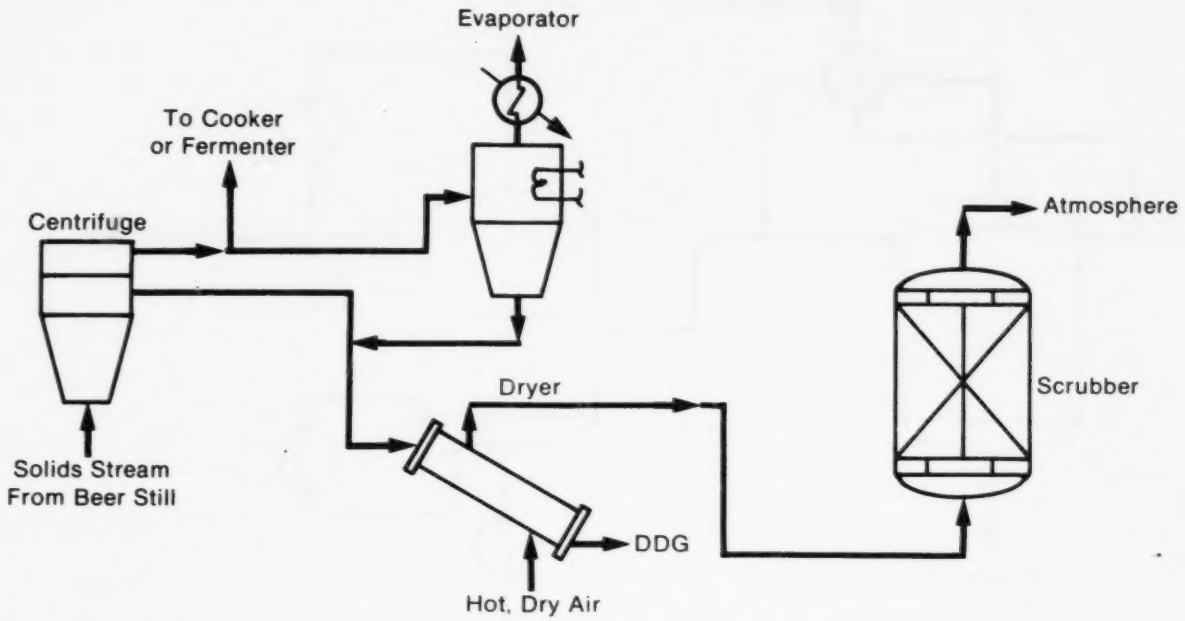

Figure B-5

DEHYDRATION AND DENATURING WITH GASOLINE

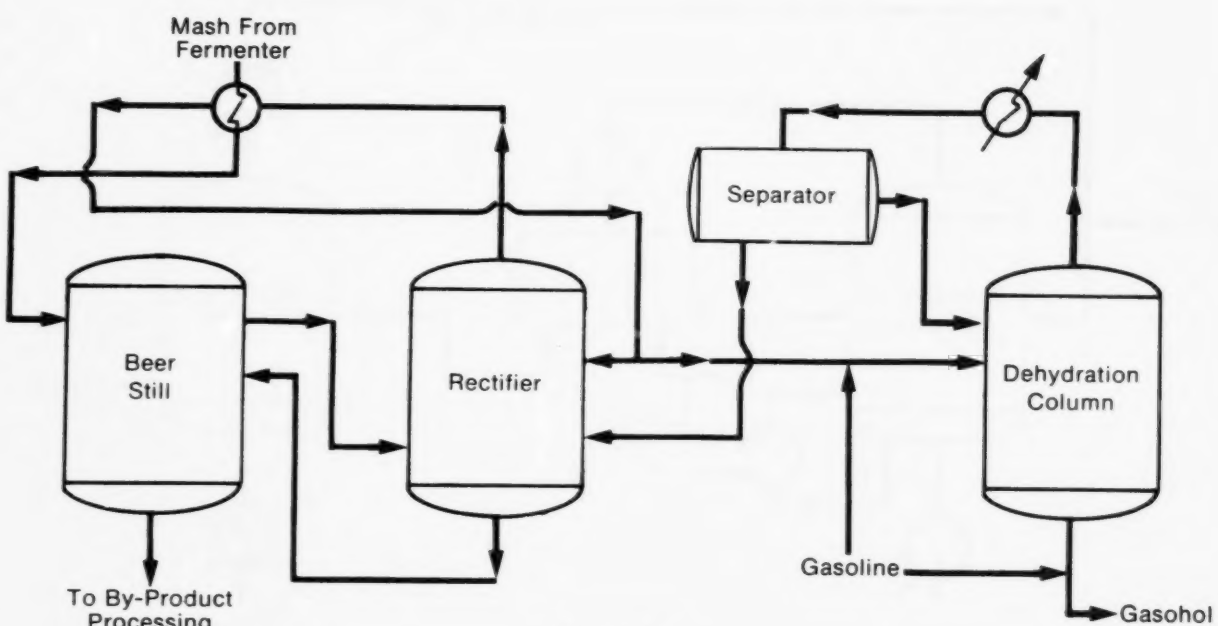

Figure B-6

CONTINUOUS FERMENTATION

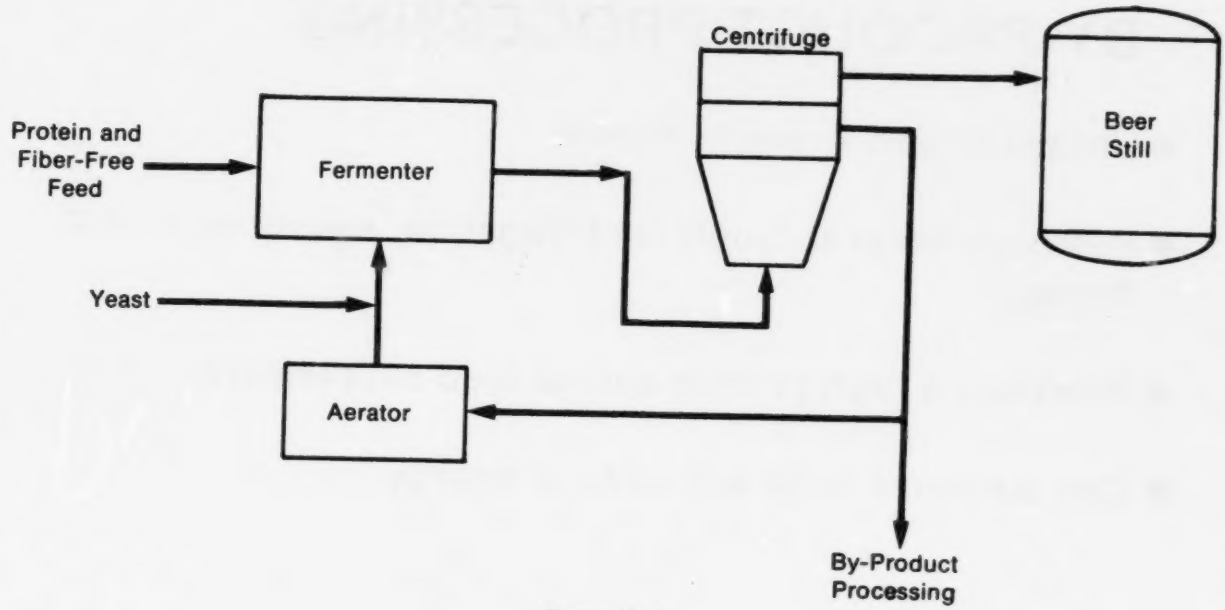

Figure B-7

VACUUM FERMENTATION

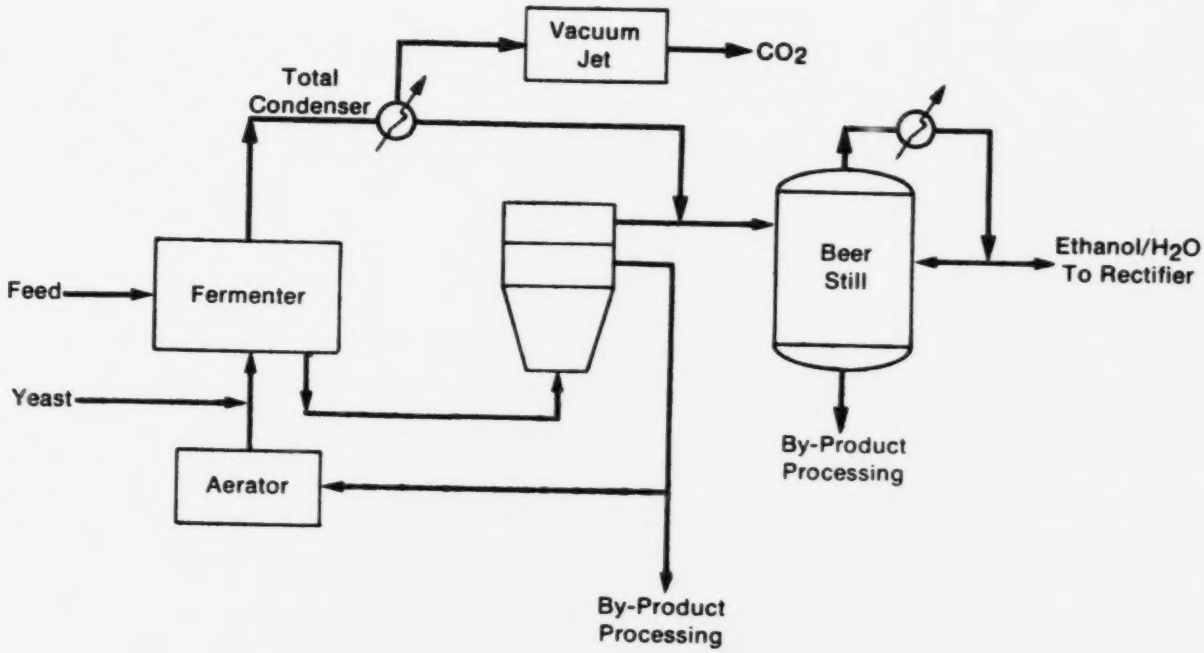

Figure B-8

BY-PRODUCT PROCESSING

- Utilizes a high strength stream
- Removes water through centrifugation, evaporation and drying
- Produces a high protein animal feed supplement
- Can consume large amounts of energy

Figure B-9

THE FARM ENERGY PROGRAM

by
William Scheller, University of Nebraska

The Farm Energy Program is the subject I am supposed to speak on, but I am not quite clear where the boundaries are on this topic. Of course, the farmer's main concern today is diesel oil, but I don't think that is what we are here to talk about. More specifically, what I want to speak about is the farm alcohol plant, the production of alcohol in small plants on farms. I think in order to understand this, we have to understand the personality of the farmer. Could I have a show of hands of how many of you have grown up in a rural area or lived on a farm? (The gentlemen in the audience complied.)

Then it is not necessary to describe life on the farm to this group. The farmer is continually at someone else's mercy, whether this be the elements or whether it be major companies, big business, as he sees it, but he has this strong compulsion to be independent -- to be totally independent. I think if we look at the farmer's situation carefully and realistically, we see that he is one of the last holdouts for a true, free enterprise system. He has never organized into a union or an association that will control production and set the price on his products. He works for probably below minimum wage in many cases. When he looks at the money he has made at the end of the season, he would, as a result, like to feel he has some control over his own destiny. Well, there are a lot of things involved in controlling one's own destiny. One of the immediate concerns is that the farm has become highly mechanized and to maintain this mechanization and maintain the production levels and farm these large acres of land, the farmer needs fuel. I am sure you all have read in the newspapers the concerns over diesel fuel supply and most recently the comment that diesel fuel for farm use was going to be removed as a number one priority, so the farmer is feeling insecure.

Well, what does this really mean? I have not made a comprehensive study of this, but one farmer who I have a good deal of respect for and who does not tend to exaggerate (except when he speaks of his ability to produce cattle) was telling me of an instance last year. He has center pivot irrigation equipment on three quarter sections of land and he has historical records on the productivity of this land. Last year, due to an error, when it was time to turn on the irrigation equipment, the center pivots got turned on two sections but not on the third section, and it was five days later that he recognized this and turned on the irrigation equipment on the third section.

The corn productivity on that third section was 10 bushels per acre less than the productivity on the other two sections where the irrigation equipment was turned on at the right time. Ten bushels per acre for 160 acres is 1,600 bushels of lost corn production at $2 a bushel; that is $3,200 in income that was lost for a five day delay in irrigation.

I think many farmers again see the situation developing where maybe they will not have the fuel to turn on that irrigation equipment at the critical time simply because fuel will be in short supply and they will not be able to get the fuel delivered.

On the other hand, we know that there is a lot of grain stored on the farms. In Nebraska, for example, the recent figures that I read said that we have stored in Nebraska somewhere around 500 million bushels of corn. Our corn production last year was 700 million bushels for the State of Nebraska. About half of this corn, perhaps a little over half of the corn, is stored on the farm rather than in commercial grain elevators.

So the farmer looks out on his corn storage equipment saying "Gee, you know, I could make some fuel out of this corn." Well, how much fuel could he make? I think a pretty well-accepted figure on industrial production is 2.5 gallons of alcohol per bushel of corn. However, in a small plant, the farmer might not be able to get 2.5 gallons of alcohol per bushel but only 2.4 gallons per bushel. But this really does not concern him.

If a farmer were to convert five or six percent of his corn crop into ethanol, he could power his irrigation engines, assuming they are internal combustion engines, with ethanol. He could put about 20 percent ethanol in all his moving machinery. There is no farmer that thinks he is going to set up his own industrial chemical complex. So the amount of energy needed to run equipment on the farm is relatively low, and five percent of his crop would provide enough alcohol to satisfy his energy needs.

A small ethanol plant producing 20 to 30 gallons per hour of ethanol would use 8 to 10 bushels per hour of corn. The farmer with a thousand acres of corn could easily produce his alcohol fuel needs during the winter months; to power such an alcohol plant the farmer might burn the corn stalks, corncobs from that 8 to 10 bushels of fermented corn mash that he distills. The farmer needs only to use ag-residue from the bushels of corn mash distilled to be energy self-sufficient.

All of this is practical, the combustion equipment is there and the farmer considers it attractive. Today small plants are being proposed that are really pretty much miniturized commercial plants. The alcohol to be produced is 190-proof. I do not know any small plant proposals that include dehydration of the alcbhol, and, as was mentioned earlier, the by-product cattle feed would be fed wet. Therefore, additional energy would be needed for alcohol dehydration or drying distillery grains.

What do the economics look like on the small plant like this? This is another place where a farmer has an advantage, because he has his own economics and these may be very different from the business economics that we are used to dealing with.

I think the farmer's principal consideration is what the plant is going to cost. There are two firms that are considering, or actually in the process, of putting on the market a small alcohol plant of the size range that I mentioned of producing 20 to 30 gallons per hour of ethanol. Neither of them has a completely firm price as yet, but they are proposing to sell the major equipment to the farmer. For example, the manufacturers do not see any reason for buying a bunch of pipes and shipping them to the farmer when the farmer can purchase those locally. It will be necessary to pour some kind of a concrete pad as a base for the plant and construct some kind of building to keep the plant out of the weather. These things are not included in the price which is in the order of 20 to 25 thousand dollars.

By the time the farmer finally builds this plant, he will have probably around $40,000 invested. This amount is not too bad when you see that he spends $40,000 to $50,000 for a tractor. The price $40,000 doesn't scare the farmer. He is used to having equipment in that price range; he is accustomed to using equipment only part-time and, the general thinking among the farmers is that in the winter, or at least when they are not extensively involved with their farming operations, they could be running their alcohol plant.

It is not quite clear yet how automated these plants will be, so it is not clear how much time the farmer will actually have to devote to watching the plant to make sure that it is running properly and safely.

If we consider a situation where the farmer might produce 6,000 gallons per year of ethanol in a plant which costs $42,000, he would have $7 per annual gallon of alcohol produced as his investment. A commercial plant of 20 million gallons per year might be in the order of a $1.50 per gallon of annual capacity.

Now, 30 gallons per hour of ethanol, if we think of an around-the-clock operation, seven days a week is a quarter of a million gallons per year production. I do not know if these small plants could really run for long periods of time without shutdown, even though they are supposed to have an operating factor in the order of 92 or 93 percent. If the farmer paid $42,000 for a plant and produced a quarter of a million gallons per year, that would be $1.68 per gallon of annual capacity which is comparable in investment to a very large plant.

I talked to a farmer about his labor and tried to include labor in the cost of producing alcohol. He said, "Oh, I don't want to charge anything for my time." I told him, "Gee, that's great; you know, if you would come up to my house I have a garden at the back of the lot that needs some tending, and if you would do that for nothing, I would be much appreciative." Well, that is a different story. When he is working for himself to produce something he needs, he does not seem to want to put a value on his time.

I brought up the matter of maintenance and maintenance cost during the discussion, and again he said, "Well, if I have to repack a pump or something like that, I will just pay for the pump packing and do the job myself. I'm not going to worry about what value my labor adds to the price of alcohol." I think he may be justified in this kind of thinking, because he has a more deep-seated understanding of what his problems are, and the most important of which is the last increment of fuel needed in his farming operation; otherwise he is going to lose one whale of a lot of money. Putting it another way, the value of that last increment of fuel is very high to the farmer. So whether his plant is costing him $7 in investment per gallon of alcohol produced or whether it is less or whether he charges his time or does not charge his time, he knows that last increment of fuel is probably worth $5 or $10 a gallon to him. He is pretty confident that the alcohol he produces is going to be cheaper than that, and I am inclined to agree with him. He has not worked his way through the energy economics the way business people might do, but on the other hand, he has found a real justification for producing alcohol on his farm.

What about the environmental problems that might be associated with the Farm Energy Program? I guess I would have to start out by saying that environmental control considerations are not really my bag, but I do see some things that might cause a problem. The farmer generates 50 gallons per hour, approximately, of wastewater during the plant operation. Now remember, if his plant can produce 30 gallons an hour of alcohol, and if he is going to produce 6,000 gallons of alcohol annually, he is going to generate approximately 10,000 gallons of wastewater per year. I think the BOD in that wastewater might be on the order of 1,000 or 1,200 parts per million. There is definitely a plant wastewater problem that needs attention. Now to look at the boilers that will be part of the plant.

The potential sellers of these alcohol plants are buying conventional low-pressure boilers for generating steam for the plants. They want to be sure that the farmer does not need a second class engineering boiler tender's license in order to operate the alcohol plant.

The boiler is a small commercially available fire tube type boiler, good efficiency, up to the 85 to 86 percent, and burning probably on the first pass some kind of fuel oil, liquid fuel rather than corn stalks and corncobs. I think these boilers already meet certain standards and the boilers are already sold commercially. I think they meet all EPA standards as far as the stack emissions are concerned.

There may be an odor problem with the fermentation process. There is a vent on the fermentation vessels which vents the carbon dioxide to the air. This vented carbon dioxide carries with it a little bit of ethanol. Of course, this will have an odor of a bakery, a typical yeasty-type odor. Whether this is objectionable or not out on the farm, I can't say. But there could be a disagreeable odor which could easily be cleaned up with a little scrubbing apparatus on the vent.

The environmental problem that I am a little concerned about is that the plants which are proposed for th

farmer are batch fermentation plants and every now and then there is going to be a bad batch of fermentation. This bad batch is going to wind up as some kind of slop that contains no alcohol and cannot be distilled.

In the simplest case, the bad batch would contain acetic acid which probably can be spread on the land. The worst case I can imagine might be a badly contaminated batch which consists of some kind of a slimy, smelly mess. The farmer has in the order of 5,000 gallons of this mess and now he has to get rid of 5,000 gallons of something he does not want and cannot feed to livestock. What is he going to do with it? He would probably haul it out and dump it in the field. It is all organic material, as far as that is concerned. It contains a few ammonium compounds, which are nutrients for the yeast; but, he puts ammonium compounds on the land anyway for fertilizer. If it is in the summer, it probably would attract some flies. He also might want to plow it under. The question is what are the environmental effects of this type of waste disposal? Are there any other alternatives?

If all this is going on in the winter, when the temperatures are low, I suppose there will not be odor problems, except probably with the melting of snow. Again, I am thinking of basically Nebraska, Iowa, Kansas and Minnesota type environments on this.

A lot of the soluble materials in the spoiled mash are going to be leaking down into the ground and possibly contaminate the groundwater in the area where the farmer has dumped this material. However, another possibility which has been investigated by Cloddsbury in Milwaukee some years ago and at Schlitz, too, is storing wet brewer's grain by digging a pit and filling it, creating basically an anerobic condition. They have been able to store the wet grains for a month or more in this fashion. The farmer might be able to work his way out of a temporary problem without a dryer and still save the grain by putting it into some kind of a pit silo. These are some of the problems that I see. The farmer handles grain and stores grain on his farm every day, so storing wet grain will not be a new problem.

If there are any environmental controls regarding his loading corn into a truck or moving it from one place to another, the farmer is already familiar with these regulations. I think the new problems will begin once he starts producing alcohol.

Jim Mandia said that I should also mention something about possible research projects that might go along with the on-farm production of alcohol. The first project is, of course, to look at the farmer's potential problems with on-the-farm alcohol production from an environmental standpoint and determine if any good ways of handling these potential problems can be found. This information should quickly be made available to the farmer so he can become familiar to thinking along these lines.

Since my principal work in alcohol production is in processing, the research ideas I envision are mainly in this area. This includes alcohol recovery by nondistillation type separation; such as membrane separations, liquid extraction, and selective absorption.

These processes might be very beneficial to the small on-farm plant since most of the energy to produce the steam is used for the distillation section of the plant. If the farmer could replace distillation with one of these other processes, he could reduce the steam requirement, the condensation production and, hopefully, then some of the wastewater effluents from the plant.

Continuous fermentation is another area that is of interest to the farmer. It would be pretty nice if the farmer could ultimately have an alcohol plant where he fills the hopper with corn, goes about his business while at the other end, fuel comes out of one pipe and cattle feed runs into a trough. He wouldn't have to worry about what was in that black box.

Well, so long as we have batch fermenters, the farmer does have to worry about what is in that black box; if he had continuous fermentation, it would free him of some of the responsibility associated with operating a small plant.

Of course, another area in which to experiment is in cellulose hydrolysis. The hydrolysis facility could also be a small on-farm plant. The farmer has residues such as corn stalks, corncobs, wheat straw, etc., that might hydrolysize to glucose and then in turn, ferment to produce ethanol.

The potential of cellulose hydrolysis is in the fact that it creates an incremental fuel. A small on-farm hydrolysis plant could process even egg residues as a source of glucose for producing alcohol. Other areas for research are in the production of other fermentation products in addition to ethanol. For example, there are organisms which can utilize pentases to produce butyl alcohol and prophyl alcohol.

The farmer is interested in any kind of liquid fuels. These higher alcohols tend to be more like hydrocarbon than water and, I might add, alcohols lie somewhere on a scale between water at one end which is HOH, and alcohol which has some kind of hydrocarbon group (R) and is indicated as ROH. Methanol is closest to water since it contains only one carbon atom for R. Ethanol contains two carbon atoms. It is further away from water and actually, it lies pretty well between these two because it is completely soluble in water and completely soluble in most hydrocarbons. As we move down the line to butanol and pentanol and so forth, we find situations where the alcohol is no longer completely soluble in water but is soluble in hydrocarbons. The propanol and butanol are moving down toward the hydrocarbon end of the scale and they are certainly good fuels. They have high heating values. The octane number, however, is a little lower than that for methanol or ethanol.

Another product which can be produced by fermentation is acetone. I do not know what the

environmental effect might be of burning acetone as a fuel in the internal combustion engines. Probably aldehyde levels would become very high in the exhaust emissions.

Finally, research is needed in the use of thermophilic organisms for ethanol production. Actually, there is almost an endless amount of research work needed to develop the on-the-farm energy program. I get calls every day from three or four farmers wanting to know something about alcohol production, small plants, how to burn it in diesel engines; a lot of these calls and questions, the farm energy program could just about use up the Gross National Product on alcohol research. There are many, many unanswered questions.

Mr Struzeski: In reference to the small farmer, why does he limit production to 6,000 gallons per year and how many fermentation batches does this require in a year?

Dr. Scheller: In order to understand the 6,000 gallon alcohol production limit, it is necessary to view the total farm energy picture. Most of the engines are diesel engines. Alcohol and diesel fuel cannot be blended in the same way that alcohol and gasoline are blended.

The simplest way to handle the alcohol/diesel system is to put a carburetor into the air intake for the diesel fuel and provide a second alcohol fuel tank and carburate the alcohol into the diesel cylinder while the diesel fuel is still coming in from the fuel injection system as it normally does. This way, only a percentage of the alcohol is burned in the diesel engine.

The number of gasoline fueled engines on the farm is relatively small. Gasoline engines operate the pumps for the irrigation system, and these engines can be modified to run on straight alcohol.

The goal of the farmer is to have sufficient fuel to operate his farm. When gasoline supplies are not available, he can convert the gasoline engines to run on straight alcohol by changing the carburetor jets and by running the alcohol fuel line close to the exhaust line so that the alcohol can be heated as required for operation. All that is required to convert an engine from gasoline to alcohol is to change the jets and preheat the fuel. The engine efficiency may not be up to what it was with gasoline, but if gasoline is not available, farmers can continue to operate their farms. There really is no potential for replacing 100 percent of his fuel needs with alcohol.

So 6,000 gallons of alcohol is sufficient fuel to operate the average farm for a year. Now if he has 6,000 gallon fermenters and if the alcohol concerntration in those fermenters is 10 percent, producing 600 gallons of alcohol in a fermenter, he is going to need somewhere in the order of 10 fermenters to make 6,000 gallons of alcohol.

He could manage this, he feels, as a chore after dinner; all that is required is a trip to the barn to start a batch. This is his attitude.

Dr. Coffin: I guess the spirit on the farm has changed since my day. We used to have a spirit of cooperation, one farm helping another. We did a lot of work like this. I wonder if there is any tendency to consider this in building these alcohol plants.

Dr. Scheller: I have actually urged the farmers to get together with their neighbors and pool their $40,000 to buy something bigger and ultimately they could buy a plant that could produce a large amount of alcohol; then they could afford to hire an operator, or more than one operator to run the plant around the clock. They do not have to worry about what they are going to do if they want to go down to Florida for two weeks and have a fermenter full of mash that should be processed through the still.

I reminded them that they got out of the dairy business because they did not like to scrub all of the stainless steel equipment and meet the health standards that were associated with producing milk. I also reminded them of the fact that before they put a charge into their fermenters that those fermenters are going to have to be sterile. They are going to be performing the same kind of cleaning and sterilization duties with fermenters which they did not like in the dairy business. If they had a big enough plant that they could hire somebody to do all of this, then it could be an investment.

Dr. Coffin: If they could come out better on their capital investment, that is the way to do it.

Dr. Scheller: Yes, it depends on how you look at the capital investment. If it is per gallon of alcohol actually produced in a year, the investment is quite high if you consider continuous operation, producing say a quarter of a million gallons per year for $40,000. Well, you are not going to beat that with a bigger plant. However, it is low considering 6,000 gallons per year production for $40,000. Again, it is hard to determine the economics of small alcohol plants. I have a feeling that, in the long run, the farmer would be better off pooling his money and building a larger plant.

He prefers to have, on the other hand, his own plant down in the barn because it gives him a feeling of security and perhaps a pride of ownership. But what I am concerned about is after the novelty wears off is that $40,000 investment going to sit there after it has been used for only a year or two and collect dust?

Mr. George: I just had a question and a comment on Dr. Coffin's remarks. There is a very similar situation out in Southern California where the grape growers have banded together to consolidate their costs. Winery out there, the sweet wine market out there, has a distillery right next to it. If they can't put their grapes on the table and make raisins out of them, they turn them over then to the co-op and make sweet wine or commercial grain or high-proof alcohol. It seems to work pretty well with a minimum amount of acrimony.

I think it is an excellent way to manage a vineyard. Each grower puts in so much money to fund the co-op.

question is — could you expand your remarks a little bit, Dr. Scheller, on the type of still that you were referring to that could be commercially available for the farmer? I was curious about that.

Dr. Scheller: Yes, these stills are single columns with a lot of trays in the order of 40 to 50 trays for simple fractionation and a column taking 190 proof off the top. There are other designs which use direct steam injection into one distillation column with no trays. You know, if the column is going to be put in a building, the farmer does not want to build a skyscraper; he feels these columns should not be higher than about 13 or 14 feet. So actually, there are four columns standing side by side, but they operate as one fractionation column. There is only a reboiler at one end and a condenser at the other end.

Mr. George: So, it is like a pair of columns, a pair of rectifier columns?

Dr. Scheller: Yes, right.

Mr. George: That will produce over 190 proof?

Dr. Scheller: Well, yes. One hundred ninety proof is a term that the farmer learned and recognizes.

Mr. Mournighan: Aren't the four split columns pretty complicated for the farmer to operate?

Dr. Scheller: No, not really. With some level controls in the bottom of each column section, you can pump the liquid back to the top tray of the next column down a well-insulated vapor transfer line.

Mr. Mournighan: So this is not just something a farmer can throw together?

Dr. Scheller: Oh no, this will be a part of the kit that he buys.

Mr. Mournighan: It appears to be rather sophisticated.

Mr. Lawrence: If the farmer does not dry the stillage by-products will he dump it or feed it?

Dr. Scheller: He will probably feed it wet. He will only dump it if he gets a bad batch of fermentation or if he doesn't have enough cattle around to feed. A significant percentage of his herd must be maintained, otherwise he will wind up with more distiller's grains than he can feed.

Mr. Lawrence: You quoted a price of $42,000 per plant. That certainly isn't a one-year captial investment.

Dr. Scheller: That is the farmer's total cost in buying the kit and erecting it.

Mr. Lawrence: It is really not fair to figure amortizing the 6,000 gallon $42,000 plant over one year at $7 per gallon. The plant has to be amortized over a period of time.

Rogers: Does the on-the-farm scenario include on-site processing of grain rather than a centralized processing area?

Dr. Scheller: Yes, the scenario includes on-the-farm milling. I think the farmer is going to have the complete crop-to-alcohol process right there on his farm.

Mr. Rogers: Because of the acid nature of the residues from fermentation, would it be wise to attempt to ferment such material anaerobically to produce methane?

Dr. Scheller: The acidity would have to be neurtralized, but the methane could be used as fuel for the boiler. I think the costs of producing methane and the capital investment required would be important factors to consider. The production of methane could be an add-on to the alcohol farm energy program. The farmer could build an alcohol plant and if he wasn't satisfied with the feeding operations he could have had an anerobic digestion system to take care of the stillage.

Mr. Dial: From your association and understanding of the farmers, do you feel that any of them are thinking of producing alcohol for purposes other than their own use? Do they see it as a money-making proposition, rather than a survival situation?

Dr. Scheller: If the farmer can produce some extra alcohol and his neighbor does not have a plant, he would probably sell some to him. There have been some people (not farmers) who have tried to promote the idea that the farmer should place alcohol in milk cans out at the roadside; a truck picks up the cans (similar to the milk pickup); and then takes them to a central processing plant where the alcohol is converted into 200-proof for blending. I have not explored the economics of this kind of operation.

I think the farmers first thought is basically to produce fuel for himself. If he has extra production capacity and has a neighbor who needs fuel, he would consider producing and selling to his neighbor. I don't think, however, that any of them would really do this as a commercial venture.

Mr. Shiel: The farmer can produce alcohol on his farm, as I see it, and from the comments I have heard, he can utilize the so-called down-time that he has on the farm as he chooses. He will not take time during the summer when he must be out there changing the irrigation pumps, pulling his corn and what all he does. But, he is looking for this three month period in the middle of the winter when he doesn't have anything else to do.

Dr. Scheller: That is right.

Mr. Shell: He is not looking for a year-round production. He is looking for three months and 20 days out of that three months would just about take up his relaxation time, his work time and his hobby.

Mr. Dial: Well, that sort of ties in with the point that I was trying to make. It appars to me that eventually the farmer could build a co-op group; it could be an actual income

source, as well as a source of alcohol that is assured to him through the co-op. I just wonder if the farmers are giving this idea much consideration?

Dr. Scheller: At this point, I think there is still too much enthusiasm among farmers in regards to owning their own plants. But again, I think I mentioned that one thing farmers ought to consider is the possibility of pooling their money and putting up a larger plant and this would be a cooperative arrangement. They could bring their grain in for processing and receive their quota of alcohol and cow feed. This would give them flexibility; if they needed more fuel and more cattle feed, they could get it with established credit at the co-op. It offers a lot of flexibility in establishing the balance between alcohol and cattle feed that is needed. Also, this will improve the economics of the alcohol production.

Mr. Ortman: The farmer has a bushel of corn. Is it more profitable for him to use it to make ehtanol or sell it?

Dr. Scheller: Here again, Gordon, it depends on how you evaluate the economics. If you evaluate the economics in terms of needing ethanol to meet the fuel needs on the farm, then he is way ahead making the alcohol rather than selling the corn. If he has to have this alcohol to compete with diesel fuel, which he can buy from his local supplier, then he probably ought to sell the corn. His concern, his whole interest in this, is to assure sufficient fuel to run his farm and in that case, it is better decision to make the alcohol.

Mr. Ortman: Dr. Scheller, have you performed an energy balance on the processes involved in the production of energy on the farm?

Dr. Scheller: I have thought about doing this; however, I haven't the necessary data available to accomplish this at the present time. One of the things that will greatly help the farm energy program is the high thermal efficiency of small boilers. Superior Boiler Works, Hutchison, Kansas, for example, tells me that they can provide boilers that produce 25,000 pounds an hour of steam with a saturated steam of 15 pounds per square inch, with a thermal efficiency of 86 to 88 percent.

Mr. Ortman: Burning fuel oil?

Dr. Scheller: Burning fuel oil. I have talked with some of the producers of some of the commercial boiler plants that make boilers to be installed in the 20 million gallons a year grain alcohol plants. These boilers cannot compete with that kind of efficiency at all. Maybe the balance of energy is pretty good using these small boilers as the principal source of heat for the farmer's still. Apparently, they are very efficient.

Mr. Ortman: Is it possible to use the stover for a fuel rather than putting it back on the land?

Dr. Scheller: Oh, I think it is certainly possible. There are on-the-farm plants designed to utilize this kind of fuel and burn it efficiently and effectively. To use stover to fuel a commercial boiler, I think the farmer would have to provide a separate combustion unit, a separate fire box, and then pipe those hot gases around into the boiler. It would have to be some kind of add-on arrangement, I am sure. You know, farmers are very inventive individuals and we are going to find farmers building small combustion units and supplementing the fuel with biomass or even replacing the liquid fuel with biomass.

Mr. Ortman: If we have sufficient petroleum power available to us, I do not think it would be economically feasible for this country to go to gasohol.

Dr. Scheller: I do not agree with that. The only way you can find out whether something is economically feasible or not is to determine if it is available in sufficient quantity, and its price. At some price alcohol becomes a more economical fuel than gasoline.

Mr. Ortman: Are we at that point now?

Dr. Scheller: Yes, I believe we are with the small on-the-farm plants. I do not believe alcohol from farm plants is going to compete in the marketplace as an alcohol source.

Dr. Coffin: It seems to me it would be more economical to ferment stillage anaerobically producing methane as a fuel rather than using it to feed livestock.

Dr. Scheller: That could be true, but again, I do not know the costs involved in methane production. Certainly, in looking at the overall energy needs of the farm plant, this appears very attractive.

Mr. Lawrence: I understand that to use fuel oil to produce alcohol probably requires less energy than the amount of alcohol that is produced; that is if the alcohol is not dehydrated. The intent then would be to use the low proof alcohol only in diesel engines.

Dr. Scheller: During the summer months 190-proof ethanol can be mixed with gasoline and not risk having a phase separation problem. The farmer could also use it in his gasoline powered engines in the summer. The farmer can convert his spark ignition irrigation engines to run on 190 proof alcohol.

Mr. Lawrence: They could run on a lot less than 190.

Dr. Scheller: Yes he could, that is right.

Dr. Coffin: What would be the relative portion of fuel oil required to produce a gallon of alcohol?

Dr. Scheller: Until we get a good energy balance on a small plant, I cannot really answer that. Since we do not have a dehydration step in producing alcohol in a small plant, we save one energy source that is required in a commercial plant. The farm plant has a boiler with a high thermal efficiency and I am sure that on a BTU basis fewer BTU's of fuel oil are used in producing the alcohol than the BTU content of the alcohol produced. What this difference is , I do not know. Whether it is 1,000 BTU's per gallon, or 10,000 BTU's per gallon, I am inclined

think from the flow diagrams I have seen that the small plants have the capability of having an energy balance that a large commercial plant would really envy.

DEPARTMENT OF TREASURY REGULATIONS
Farm Production of Alcohol

by
Thomas George, Bureau of Alcohol, Tobacco and Firearms
Washington, D.C.

My name is Tom George, and I am Chief, Regulations and Procedures Division for the Bureau of Alcohol, Tobacco and Firearms.

This marks about a ten year anniversary for me. About ten years ago next week, I went up to Cloverdale, California and gave a little talk on the Gun Control Act of 1968. The audience was very hostile -- to say the least. I always like to plan my talk so that it will go through a certain period of time, 10 minutes, 15 minutes, something like that. I started looking at my watch and someone in the audience hollered out that I didn't need that, there was a calendar right behind me. So anyway, today, I won't take too much of your time.

ATF, or the Bureau of Alcohol, Tobacco and Firearms is responsible for administering taxing statutes in the Internal Revenue Code of 1954 which relate to distilled spirits, or ethyl alcohol. These laws, while the guidelines within which all producers of ethyl alcohol must operate. In previous years, the Bureau's principal involvement has been with the beverage alcohol industry. The main mission of the Bureau, under the Internal Revenue Code, is protection of the revenue. We collected approximately $5.4 billion in 1978. With this much of a financial interest, it is easy to see why the federal government is involved in regulation of the alcohol industry.

For many years people have proposed various ideas for using ethyl alcohol for fuel. It was used in Germany during World War II. There were some books published in the 1940's that talk about using it in the United States. Of course, with the cost of energy now, we are turning in that direction in this country.

In any event, I would like to talk today about our controls over the distilled spirits plants; how ATF qualifies distilled spirits plants, and the program the Bureau has embarked on to make things a little easier for the small producer of fuel alcohol.

We have two types of distilled spirits plants that are authorized by law. The first type is a commercial distiller and the second is an experimental plant, for the person who wishes to experiment or develop new processes with the use of alcohol.

The first type of distilled spirits plant that I am talking about is a commercial facility, one which is authorized to operate by the government with an operating permit under the Internal Revenue Code. This plant can either produce alcohol for beverage use of alcohol for commercial purposes, such as denatured alcohol. I might mention that there are two types of denatured alcohol. There is completely denatured alcohol which we talked about earlier, and there is specially denatured alcohol which is used in products like perfumes, shaving lotions, hair tonics or mouthwash.

To qualify as a commercial distilled spirits plant is a very complicated process. The premises and buildings have to be constructed in such a way as to provide very substantial security for the purpose of revenue collection. We have ATF officers stationed at these plants.

At these plants, we literally maintain security by locks and keys under control of our assigned officers. A commercial distillery is also required to post a bond which will cover the potential tax liability on this alcohol. The present tax is $10.50 a proof gallon, which amounts to about $1.70 for your favorite fifth or 750 milliliter bottle of bourbon. By comparison, the tax is a small part of the price of bourbon but there is quite a substantial difference in tax for a gallon of absolute alcohol. Here the tax is $21 a gallon. Our taxing statute is set up on a gallon of 100 proof alcohol, so when you have 200 proof alcohol the volumetric gallon turns out to be two proof gallons from the viewpoint of taxation. That means the potential tax liability to the government is about $21 a gallon for fuel grade alcohol.

You can easily see that if a person wishes to qualify as a commercial distiller under the present law, it would mean a significant investment in time and money.

The second type of plant authorized by law is the experimental plant. The law imposes less stringent requirements than those required for a commercial distiller. We have waived most requirements and have proposed liberalizing legislation.

The premises for an experimental plant can be any suitable site where one could build a distillery. We do not assign any ATF officers to these plants. We only require very basic records of operation. The commercial distiller must, on the other hand, maintain very comprehensive records system. This system not only provides protection for the taxes, but provides us with statistics which can be used by the industry members themselves to aid the commercial and business processes.

However, people who hold expermental plant permits must file a bond to cover their potential tax liability. But if the alcohol is properly used, we don't collect any tax from them.

The experimental distiller, though, is restricted in the

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conduct of his operations in two important aspects. He can't sell nor can he give away his alcohol. It must be used for and on the experimental premises, except for certain exceptions. His permit is only valid for a limited period of time. In most instances, we grant permits for two years. It can be seen that, in the existing law, extensive regulatory and statutory controls are imposed on the distillery plants.

Persons involved in the production of alcohol, whether it be for beverage use or industrial use, are required by the current regulation scheme to follow a very complicated qualification procedure, which includes the registration of the distilled spirit plant, obtaining an operating permit, filing bonds and various other documents that are required. In addition, the present scheme provides for commercial production of distilled spirits in an enclosed distilling system, which is sealed off from any unauthorized access. It also requires on-premise supervision by ATF officers.

With this in mind, the Bureau is very much aware for the need for a more flexible approach to production of ethyl alcohol for fuel use, and of the contributions which alcohol may make in providing an alternate source of energy.

During the past few months, we have received over 4,000 inquiries concerning fuel related alcohol plants in our headquarters office alone. The regional offices have also seen an increasing interest in the plants. We have seven regional offices in the major cities throughout the United States.

The Energy Tax Act of 1978 required the Treasury Department (or ATF) to recommend legislation to change the provisions of the Internal Revenue Code to simplify the regulation for persons producing distilled spirits for fuel use. These changes must be consistent with certain safeguards to protect the revenue. However, this legislation facilitates alcohol fuel production and distribution. This has been presented to Congress.

The proposal that we have drawn up provides for a simple application process for the person wishing to make alcohol into fuel. It also provides for less stringent controls than are presently enforced for the commercial distilling operation.

Senator Bayh introduced the measure on May 22, and Representative Ullman introduced the bill in the House on May 23. The changes in law which have been presented will provide ATF with greater flexibility so we can be more responsive to the needs of people wanting to produce alcohol as a fuel.

The purpose of this new law will be to simplify regulatory controls for distilled spirits fuel use by changing the Internal Revenue Code to provide for a third type of distilled spirits.

The third type of plant would be authorized to produce alcohol for fuel uses only. No other industrial or beverage use of the alcohol would be authorized. We anticipate, after the enactment of this bill, that a broad range of individuals and organizations will apply to ATF for a permit to establish a plant to produce alcohol fuel.

Some producers of alcohol will use it to make gasohol, a mixture of alcohol and gasoline, which is gaining popularity as a motor fuel. ATF desires to facilitate the production of fuel alcohol, while at the same time we want to minimize the resource costs for the individual and the government while we sustain our statutory responsibilities.

Attached to the bill we proposed to Congress was a statement of our intentions, called an Administrative Action Plan. After enactment of this legislation, ATF proposes to issue regulations in this framework.

We envision three types of fuel producers. Small producers are those producing less than 5,000 proof gallons of alcohol a year. The second category is what we call a medium producer. They will produce less than 100,000 proof gallons of alcohol per year. The large producers will be those plants producing more than 100,000 proof gallons of alcohol per year.

The regulatory control will vary with the production level The smallest plants will have the least regulation controls while the largest plants will have the most controls. All fuel alcohol plants under the new legislation will be expected to : (1) file an application to operate an alcohol production plant, (2) with the exception of the small producers, alcohol fuel producers will file a bond to cover any tax liability, and (3) they must destroy the beverage character of the alcohol be denaturation. All fuel producers must maintain security adequate to prevent the diversion of alcohol to beverage use and must maintain some system of records to keep track of how much alcohol is being produced.

We do not anticipate very much danger to the revenue by the small producer, so we would like to greatly simplify our procedures to qualify these people to produce fuel alcohol. Regulatory requirements for the medium and large producer will be somewhat more restrictive because they present a greater jeopardy to the revenue. Essentially, requirements are going to vary directly in proportion to the output of alcohol. The larger the output, the more restrictive the requirements.

Our present experience indicates a large interest in alcohol fuel production on the part of the farmers. In previous years, the statute restrictions precluded the farmer from producing alcohol for his own personal use. (Although we allowed them to use cider without any taxes on it.)

Recent developments now make this activity economically feasible and attractive and we have liberalized our requirements as much as possible. The experimental authorization is a stop-gap measure between a very restrictive, tax-oriented law, and a relaxed situation to be enacted with our Congressional

proposal.

We have adopted a liberal posture to try to simplify regulations as much as possible under the present statutes. All the qualified people who wish to produce alcohol for fuel are granted experimental plant permits. We will be very liberal about extending the two-year qualifications. If our proposal is not passed by Congress and signed by the President in the near future, we will have to administer this program under the present code, continue the policy of approving experimental plants and to renew the applications of those people who are producing alcohol for fuel.

My purpose in talking today was to inform you of the present statutory requirements, and of the proposed changes in the tax requirements that we will have in the new law.

If there are any questions I can answer, I will be happy to do so at this time.

Mr. Dial: I think I heard you say that the lowest volume producer would have less stringent requirements.

Mr. George: Right.

Mr. Dial: But you mentioned that they would have to have some kind of security arrangement and some kind of record keeping. Could you elaborate a little bit on that, and what that would mean to an individual farmer?

Mr. George: Well, I think that really we are looking for nothing more than what farmers usually lock up as part of regular farm security.

Mr. Dial: It is just that simple?

Mr. George: Right. With the type of investment Dr. Scheller was talking about, $40,000, I don't think the farmer is going to leave his alcohol plant out where it is going to be stolen. We are not too concerned at this point that security is going to be a problem.

The real problem is the bond and high premiums. I think it is about $12 to $20 per thousand dollars of bond coverage. So, if someone is going to produce 100,000 gallons of alcohol, that is quite a tax liability, and a high premium. The miximum bond requires about a $2,000 annual premium.

Dr. Scheller: Tom, could you say a few words about the actual concerns that ATF might have about alcohol from a farm plant getting into the beverage market. I know by the regulations that the government should get its taxes if alcohol is used for beverage purposes. But, what about the bootleg market, could farm produced alcohol have a potential for finding its way into that marketplace?

Mr. George: Well, there is always a bootleg market. It is just something that you can't stop. Most of our problem in the bootleg market is in the southeastern part of the United States.

Actually, bootlegging started out due to economic reasons. Folks just couldn't afford to buy beverage alcohol. But two things happened: one was an operation dry-up in the late 1950's and the other, the price of sugar started to shoot up, so the price of moonshine began to approximate that of legal liquor.

As far as the sale of fuel alcohol as a beverage on the illegal market is concerned, yes it could be a significant problem especially when the producer may have a lot of alcohol on hand and cannot sell it or use it.

Eventhough there is the possibility of illegal diversion, we are willing to take the risk. We don't have enough manpower in our Bureau to really enforce this program to the degree we would like to . Out of necessity, therefore, a lot of things will have to be ignored. It will be a very good opportunity for us to see how a part of the alcohol industry operates. We are going to say this is part of the industry, in comparison to an industry that we have regulated since Prohibition by almost over-the - shoulder supervision.

Not only is there a lot of exise tax money involved, but ATF has regulated very closely standards of identity for liquor and trade prices for the regulated industry.

Mr. Mandia: Tom, can you explain the procedure ATF uses to determine the environmental impact of these farm stills before granting permits?

Mr. George: When ATF issues a distiller's permit we look into the environmental impact of the proposed operation. We generally will not do field investigations when qualifying experimental plants.

In qualifying a commercial distillery, we send inspectors out to investigate the corporate finances and the plant premises and equipment. At the same time, we verify the information contained in their environmental and water quality statements. The experimental distilled spirits plants we are discussing are big enough to have a million gallons of distillery wastes and by-products.

Mr. Hajinian: Tom, I reviewed some of your application forms and there appears to be an environmental assessment as a permit requirement. Have you considered possibly combining the permits issuance?

Your statement indicates environmental concerns. These small plants may not damage the environment depending on where they are located. Have you thought of combining the permit issuance?

Mr. George: We have not thought about the possibility of combining efforts with the Environmental Protection Agency; however, it is an idea which deserves further study and evaluation.

Mr. Allsup: As far as the road tax credit for gasohol, do you think there is adequate control to make sure that the gasohol supplier actually put 10 percent alcohol in the product, or could he get the tax credit and blend only

one percent alcohol. Could the gasohol producer only blend one gallon of alcohol instead of 10 gallons?

Mr. George: He is going to have the IRS on his back.

Mr. Allsup: I just wondered if ATF recognized accurate blending as a problem or would ATF have control over it?

Mr. George: Not any more than we can enforce.

Mr. Cawley: We have a gasoline sampling program. Field crews are out sampling gasoline across the country for its lead content.

Mr. Allsup: Now we need to sample for ethanol.

Mr. Cawley: We don't have an ethanol sampling program now. We could certainly consider one.

Mr. George: I believe any will equipped commercial laboratory could perform the tests. Our headquarters laboratory has the equipment to perform these tests.

Dr. Scheller: I was just going to say on this matter of whether the producer is putting in 10 percent alcohol in the fuel. In many states, the Bureau of Weights and Measures would have that responsibility.

Mr. Mournighan: The same sort of thing is going on in unleaded gas and leaded gas, right now. It is an easy task to transfer unleaded gas into a leaded tank. The is why we have the state inspection system.

Mr. Dial: Apparently the cut-off point for the low on-the-farm alcohol producer is 5,000 gallons per year?

Mr. George: Right. According to the Administrative Action Plan in the proposed legislation.

Mr. Dial: It seems like that is right at the level the average farmer might be producing. What was the criteria for choosing 5,000 gallons per year say rather than 10,000. To go to 10,000 would mean that the farmer would not be considered as an on-the-farm experimental plant. It seems like you are willing to cooperate with the farmers in this. If you move the 5,000 gallon limit up you would just exclude an awful lot more producers and probably not really lose any tax. Is there still a chance of that being changed?

Mr. George: Yes, I believe we could raise the limits because they are not imposed by statute only suggested by an Administrative Action Plan. We would probably have to show good cause to Congress and the public why we raised the minimum amount, but I think we would be perfectly legal under the Administrative Procedures Act.

Under the rulemaking procedure we will issue proposed regulations to implement the new law. I would advise anybody who takes a serious interest in this to take the time and submit written comments to us. We can include these comments as testimony in the public record to possibly justify why we are raising the 5,000 proof gallon limit.

Mr. Dial: What is the timing on the new legislation?

Mr. George: S 1200 and H.R. 4215 were introduced around May 22, 1979 and as of now I don't know how far the bills have progressed. Before, I believe we had some discussion concerning completely denatured alcohol formulas, especially denatured alcohol formulas. I believe Dr. Schelier mentioned some fact about the permit system. Just briefly, I want to talk about the controls ATF has over the specially denatured alcohol formulas; I believe Dr. Scheller talked about formula 28-A.

Mr. Lawrence: That is right.

Mr. George: Right now someone could use a mixture of alcohol and gasoline and call it specially denatured alcohol. But both the producer and the user would come under the permit system in order to use specially denatured alcohol in gasoline.

Specially denatured alcohol is also used in hair sprays, shaving lotion, mouthwash, etc. So if someone wanted to use specially denatured alcohol in the production of gasohol the paper work could be much more than it is now with the experimental DSP permit.

If ATF can get a new completely denatured alcohol formula CDA 19 including only a mixture of gasoline and alcohol, this will preclude anybody having to qualify and obtain a permit as a user of specially denatured alcohol. In essence, the completely denatured alcohol route avoids a lot of paperwork.

Mr. Lawrence: Do you know why the southwest Alabama's Farmer Cooperative Association took the specially denatured alcohol formula 28-A and then they denatured it further?

Mr. George: Well, I think they made CDA-19 out of it.

Mr. Lawrence: No. They came out with a half gallon of MIBK or TBA. Five gallons of methanol and five gallons of gasoline.

Mr. George: Right.

Mr. Lawrence: I wonder why they would have to take a specially denatured formula that is already approved effective for gasoline use and then denature it further?

Mr. George: I think they wanted to avoid the paper work and expense of the industrial users permit system. ATF is trying to get the completely denatured formula changed. We have been holding discussions with our lab to see if a mixture of gasoline and alcohol would not jeopardize the revenue. The latest information I have is that the lab will approve of the formula change.

Mr. Lawrence: That seems that will alleviate a lot of problems.

Mr. George: Oh, yes, it should make it much easier. Earlier, I think there was a question about who must denature the alcohol and I believe I said that the producer of the alcohol must do the denaturing before using it as a fuel. I also believe there was some comment about a commercial still making approximately 95 percent alcohol, however, I have seen a little higher than that, up to 97 percent without an anhydrous column.

There are one or two commercial 96" column stills in the San Joaquin Valley of California. One has a rectifying column which was on top of another rectifying column. A second column was the aldehyde column and it stood off to the side. This still produced 194 proof. The other was a 96" column divided in sections instead of having the columns one on top of the other. Both stills would produce alcohol at 194 proof.

So far, information that we have on solar stills is not very encouraging, they don't seem to heat the distilling materials to a high enough temperature to get high proof products. The best information that we have is they can produce 60 and 100 proof which is not high enough.

Dr. Scheller: The place that some of these lower proofs might be used, such as 160 proof would be in the dual fuel diesel lines, that I mentioned, where you carburate the alcohol. Then you don't have things mixed and you don't worry about phase separation and standing in the tank. Jerry Allsup, I am sure, could comment on the effect of additional water on the performance of the diesel engine.

Mr. Allsup: No, we have had no experience on using alcohol in diesels, especially with the amount of water you are talking about. One of the main problems, though, is using it in tractors, where air-fuel mixture can be controlled. It is a pretty good idea. But using it in carburetors, where there are no controls, you have to depend on the carburetors doing the controlling, it has to be set up for that specific fuel formula. It can't be set up to run on low proof alcohol and then use a higher proof alcohol.

GASOHOL COMBUSTION RESEARCH

by
Richard Lawrence, EPA Motor Vehicles
Emission Test Laboratory, Ann Arbor, Michigan

Just a word of background; our reason for getting involved with the Gasohol Program was that, as most of you are aware, EPA regulates in-use fuel additives. We ran a test program on 11 cars and Jerry Allsup, down in Bartlesville, Oklahoma, ran 10 cars. In addition to that, Southwest Research, one of our contract labs, ran a couple of cars and Research Triangle Park ran a few, also.

The data that I am going to present is from our test program in Ann Arbor. What we found is shown in this first slide (Figure E-1). I will just go through the data briefly, so you can get an overview. We tested 11 cars. Four of them had three-way catalytic converters on them. There were two GM cars; a Regal and a Sunbird, and two Ford vehicles; a Bobcat and a Thunderbird. There were seven cars with oxidation catalysts; a Toyota, two General Motors vehicles, two Chryslers and two Fords.

The tests showed the percent change in emission that resulted from the use of Gasohol as compared to the use of base gasoline. Gasoline used was summer grade gasoline. The gasohol was made by adding 10 percent ethanol to the base gasoline. What we see here with carbon monoxide is a decrease in about 33 percent overall on those fuels.

Dr. Scheller: What is the significance of this observation?

Mr. Lawrence: The three-way catalytic converters which have oxygen sensors were trying to compensate for the change in air/fuel ratio that occurs when alcohol fuel is used. The converters in two Ford vehicles did not compensate for the change in air/fuel ratio.

Mr. Ortman: Was there no adjustment made in the carburetor?

Mr. Lawrence: That is correct. The cars were provided to us by the manufacturers and they all had somewhere around 4,000 to 15,000 miles on them. We verified that they were in good operating condition, properly tuned up, and we just made a gasoline run; then added gasohol and made another run. We tried to simulate field conditions in order to determine changes in emissions and fuel economy.

The next slide (Figure E-2) shows a decrease in exhaust hydrocarbons of about eight percent. The two Chrysler vehicles showed the largest decrease.

The next slide (Figure E-3) looks at evaporative hydrocarbon emissions and here we see a large increase. Now evaporative emissions occur during two periods of time; one, when the fuel in the fuel tank is allowed to be heated from an overnight soaked temperature, in this case 60 degrees to a daytime temperature of 85 degrees. This is simulated. We call this a diurnal emissions test and it simulates the overnight soak.

We also ran a hot soak test and this simulates a car which is allowed to stand for one hour upon completion of a driving cycle. We measured emissions during that period of time. We saw about the same increase. The combustion of the two is shown in this slide. Basically, there is a 62 percent increase in evaporative hydrocarbon emissions on a 3.3 trips per day basis. So this would be like on diurnal test, an equivalent of 3.3 hot soaks, which is an average number of hot soaks.

Mr. Dial: What is the reason for the Thunderbird low emissions?

Mr. Lawrence: The Thunderbird happened to be an experimental car. It had two charcoal cannisters in series. The other cars were production cars. The graph shows the effect of the increased vapor pressure in the fuel or in the front-end volatile components.

Mr. Mournighan: Is there a significant difference in hydrocarbon emissions between the emissions from the tailpipe and those from combustion?

Mr. Lawrence: Yes. From the tailpipe, emissions are given in grams per mile and from the evaporative tests, they are given in grams. So these emissions are expressed in different units. I combined them on an equivalent grams-per-day basis and the result is an 18 percent increase. The decrease from the exhaust hydrocarbons combined with the increase from the evaporatives results in a net increase of hydrocarbon on a grams per day basis.

In the next slide (Figure E-4) the oxides of nitrogen also increased. The average of all these vehicles comes out as a six percent increase.

Dr. Scheller: Are these observations consistent with the paper Jerry Allsup presented out in Asilomar? Wasn't there a reduction in oxides of nitrogen on the vehicles that were tested?

Mr. Allsup: That is a very interesting question. The data is consistent with the same data that we generated on another ten car fleet that Dick Lawrence talked about. Also, previous to that, we had completed studies on a seven car fleet. In that program we did not do the diurnal portion of this bill.

Dr. Scheller: I'm referring to the nitrogen oxides rather than the heat differences.

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Mr. Allsup: I know. But we did not measure the oxides of nitrogen and so the cannisters were not artificially loaded. In most tests the NOx was reduced. I believe the reduction was due to the test procedure employed rather than the vehicle selection or the fuel.

Mr. Lawrence: In the emission studies, we observed that the aldehydes increased.

This slide (Figure E-5) shows a percent change from the base fuel, fuel economy. It worked out with the commercial gasohol, compared with the commercial gasoline base fuel, as a 1.6 percent decrease on a miles per gallon basis. This agrees with the other four or five papers which included fuel economy measurements that were presented at the International Symposium. It is in general agreement with most data that I have seen.

Dr. Scheller: It is in disagreement with the Nebraska two million mile road test program, tests that are being run in Thailand, test that have been run in Illinois, and tests that were run in Iowa some 40 years ago.

Mr. Lawrence: What test are you referring to in Illinois?

Dr. Scheller: The Telephone Company Test, where the company emperimented with a small fleet, and the results were reported by the Illinois Department of Agriculture.

Mr. Lawrence: I have the data from the Illinois Bell Fleet and I also talked to the people who ran the program. Their intent in running the test program was due to the fact that Illinois Bell this year is on an 80 percent fuel allocation. They wanted to see what 10 percent ethanol would do to their maintenance program.

In the fleet that they used for their recent gasohol study, 15 vehicles average mileage performance was better than that observed in 1977, where 9.6 thousand miles a year was 1972 where 39,000 miles were travelled; there is no way to compare different fleet performances where there is a five year difference in models.

Dr. Scheller: Also, data published by General Motors by Brinkman, Palucci and others at the SAE meeting in Detroit in 1975, when considering their data for road speeds of 140 miles per hour, found that there was a 10 percent increase in fuel economy using gasohol.

Mr. Lawrence: I think that we have to be careful in evaluating any of these tests that report fuel economy. I feel that fuel economy depends upon typical driving patterns for a specific fleet of cars as observed on the road. I think there may be problems in evaluating fuel economy tests where the tests were performed on the EPA Driving Site.

I guess what I want to say is that, based on data that I have seen and data that I have, I am not ready to accept the statement that fuel economy decreases with the use of gasohol.

Dr. Scheller: I still, and I will repeat, I still have never seen data that says you can get better economy with gasohol. You mentioned the Illinois Bell Fleet and you have looked into that. You mentioned the Nebraska study and I would really like to see that data.

Mr. Lawrence: There is not a single statement that says 99 percent probability of a five percent increase in economy.

Mr. Koken: Were there studies made where the carburetor was adjusted to optimize performance?

Mr. Lawrence: No. We did not do any of that, for this program. We were just trying to see what would happen without any changes. I think the fuel economy per se is not really the key issue. The difference in fuel economy is very close. The average person would not notice a 1.6 percent or a two percent difference in fuel economy.

Mr. Cawley: What is the reliability of these measurements?

Mr. Lawrence: The ability to consistently repeat the same miles per gallon performance is on the order of a couple of a tenths of a mile per gallon, and the data shown here was obtained on commercial gasohol versus commercial gasoline.

We repeated the tests using indolene, which is our standard test fuel, versus the commercial gasoline. The indolene we tested contained 10 percent ethanol and we found the same approximate results.

Mr. Cawley: You don't think that two percent difference is within the noise level of the test?

Mr. Lawrence: No, in fact in those tests which showed percent reductions (1.9, 2.2, 3.9), the Toyota did come out 2.2 percent higher. This is the only test that resulted in that much improvement.

Mr. Berg: You have any explanation for that?

Mr. Lawrence: No. The next slide (Figure E-6) is a basic summary of all of that data. It shows the decrease in hydrocarbons to be 30 percent; decrease in CO, 33 percent; decrease in NOx 6.4 percent; fuel economy decreases 1.6 percent; diurnal breathing loss, which was the first part of the evaporative tests, increased 61 percent; hot soak loss of 62 percent. When we combine all of the hydrocarbons on a 3.3 trips per day basis, the hydrocarbon level is up 18 percent.

The conclusions, as shown in this slide (Figure E-7), are that the alcohol fuel that we used in the test program decreased carbon monoxide significantly, decreased fuel economy slightly, and has a potential for increasing photochemical smog as exists in such areas as Los Angeles and Denver. This is due to increased total hydrocarbon, NOx and increased aldehydes. These emissions all form oxidants which cause photochemical smog.

It may be advantageous to use the gasohol seasonall

other words, during the winter time when there is not a photochemical smog problem. It may be possible to properly blend the alcohol into the gasoline to better match the volatility characteristics for marketable gasoline in a specific area that has a high hydrocarbon level.

Dr. Coffin: Is there any data on the influence of the alcohol on the combustion engines?

Mr. Lawrence: I don't know.

Dr. Coffin: I was wondering about the increase in NOx. I had heard that the combustion temperature was reduced by the addition of alcohol. If that were so, it seems the NOx level would come down; however, your data shows it went up. Should the carburetor mixture be enriched when using alcohol?

Mr. Lawrence: Theoretically, yes.

Dr. Coffin: So your car was not running at the proper carburetor adjustment?

Mr. Lawrence: It was running at the manufacturer's adjustment.

Dr. Coffin: The car was adjusted for gasoline and not for gasohol.

Mr. Lawrence: Which is the way people will use the gasohol in the field. They are not going to change main mixture jets when using gasohol so we performed the tests in such a way as to determine what would happen when the average person begins to use gasohol.

Dr. Coffin: Apparently the carburetors were set lean?

Mr. Lawrence: Yes, about half an air/fuel ratio.

Dr. Coffin: Have you made any radiation studies of gasohol exhaust to determine NOx formation?

Mr. Lawrence: No, I haven't. We did not do gas chromatographic (GC) analysis.

Dr. Coffin: I think it would be a good idea to run a GC profile on the hydrocarbon emissions. The hydrocarbon might be significantly different in gasohol exhaust than in gasoline exhaust.

Mr. Dial: In regard to the Thunderbird which had the special cannister arrangement -- do you know if the cannister had performed as well with gasohol as compared to straight gasoline?

Mr. Lawrence: The test results indicated two cannisters were needed with gasohol in order to meet exhaust emission standards.

Mr. Dial: It is very expensive to put the additional cannister on a car, and it is only potentially effective with gasohol.

Mr. Lawrence: You are right. But in addition to the cannister, you also need to be assured that the evaporative emissions that come off the carburetor float area get through the cannister.

Mr. Dial: Do you have any idea what it costs for that extra device on the car?

Mr. Lawrence: No, and most of the cars will not have them and therefore, cannot meet the standards. This device is basically a flapper in the air horn that forces any evaporative emissions to go through the cannisters.

Mr. Ortman: Is the carbon cannister adequate to totally remove all of the evaporative losses from the cars?

Mr. Lawrence: It is designed so that the cars using indolene fuel can meet the standards to which they were designed, whether it be six grams or two grams of vapor loss. The standard was designed as available technology standard indolene fuel in mind. Certain gasolines will lose more than six grams, while others will lose much less. So the device is specifically of a standard design for use with the indolene fuel.

Mr. Berg: Why do you assume that a car which normally runs on gasoline, tuned for gasoline, couldn't use gasohol and meet the emission standards?

Mr. Lawrence: Because the way gasohol becomes available to the consumer is that the station just starts selling it. Somebody drives into a station and says fill it with gasohol. They are not going to go back to their dealer and say you have to change the main jets. They might try to make a carburetor adjustment, which is only an idle adjustment. It is not likely, however, that people are going to go back and try to do major adjustments to their systems.

Consider, for example, the Brazilian study, where the cars used up to 20 percent methanol, but the cars sold there are set up quite rich so that they can compensate for differences in fuel. When using 20 percent methanol, the car is running a little bit lean, but when using gasoline, the mixture is rich. The same thing would happen with gasohol. When the car is adjusted for gasohol, it is running fine. When using gasoline, the mixture becomes very rich and emissions increase.

Mr. Berg: What if gasohol becomes our national fuel?

Mr. Lawrence: You mean 10 percent gasohol nationwide?

Mr. Berg: Right. Then what would happen to the national fuel economy?

Mr. Lawrence: I believe that by the time that would happen, gasohol would most likely become our standard gas fuel. But from every indication I get, that is a long way down the road.

Mr. Berg: We do not have the alcohol production. What

would that do to overall fuel economy? What would it do to the overall emissions?

Mr. Lawrence: Fuel economy on a miles per gallon basis, I do not know. There probably would be a slight decrease. I still can claim that because there is less energy there. A gallon of ethanol has two-thirds the energy gasoline has. That is one-third loss; 33 percent loss at 10 percent; it should be a 3.3 percent loss using gasohol. When 100 percent methanol is used, if you make adjustments to the engine, increase the compression ratio to whatever, 13 to 1 or so and change the carburation, I think it needs a 6.8 to 1 ratio, methanol demonstrates 52 percent of the energy of gasoline and yet I think there is perhaps 65 percent improvement in the fuel economy.

Figure E-1

CARBON MONOXIDE EMISSIONS

Fuel: 90% Gasoline = 10% Ethanol

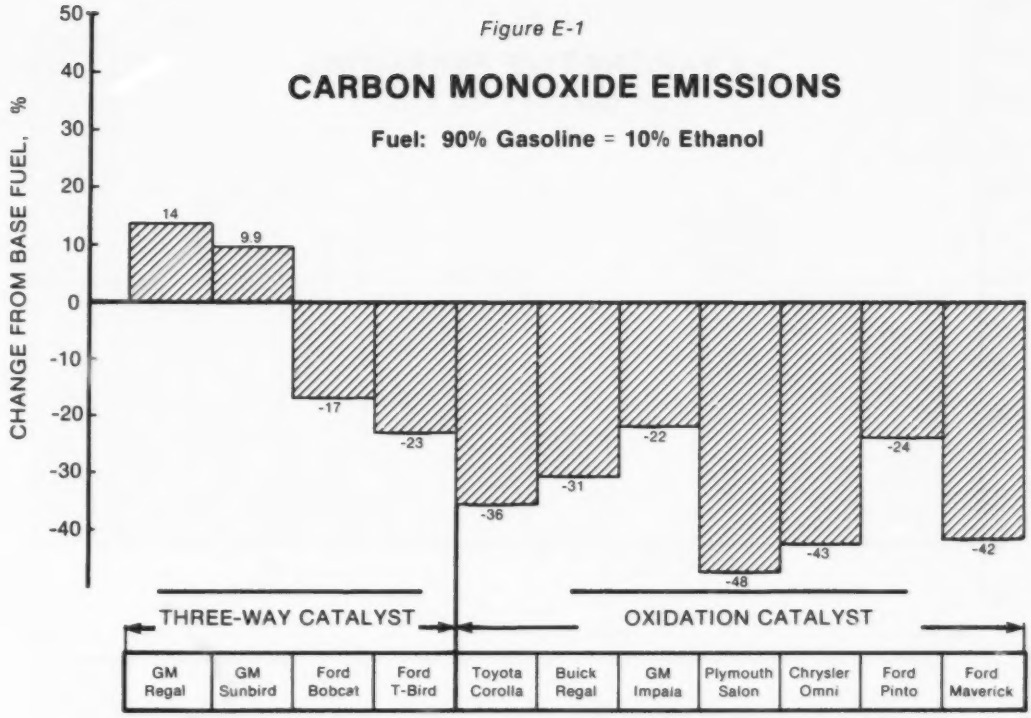


Figure E-2

HYDROCARBON EMISSIONS

Fuel: 90% Gasoline + 10% Ethanol

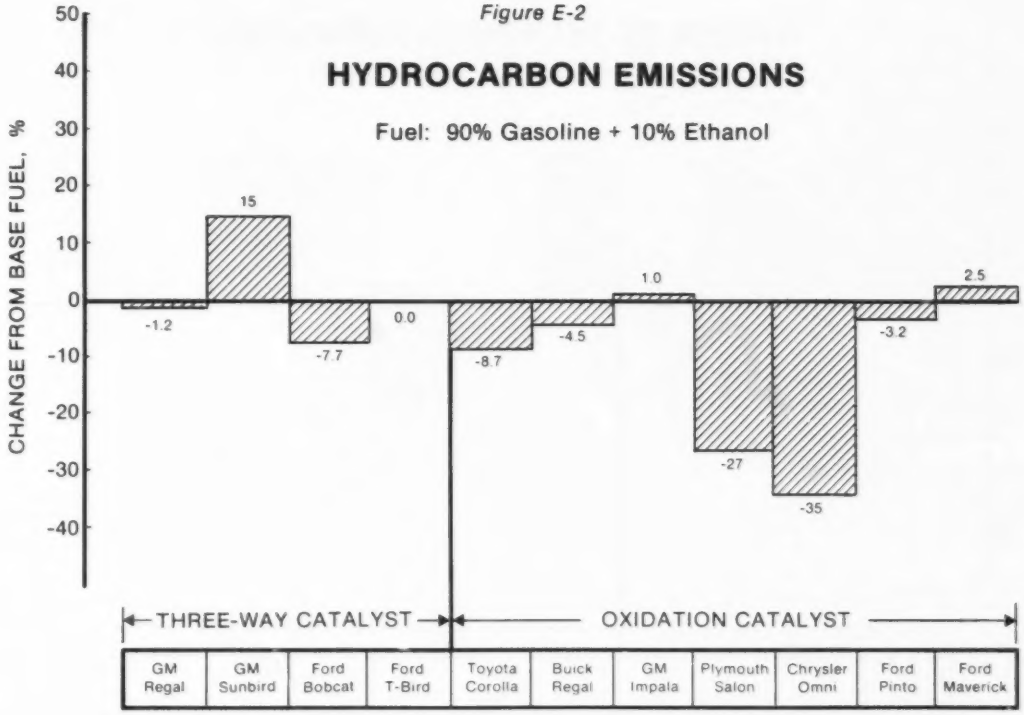


Figure E-3

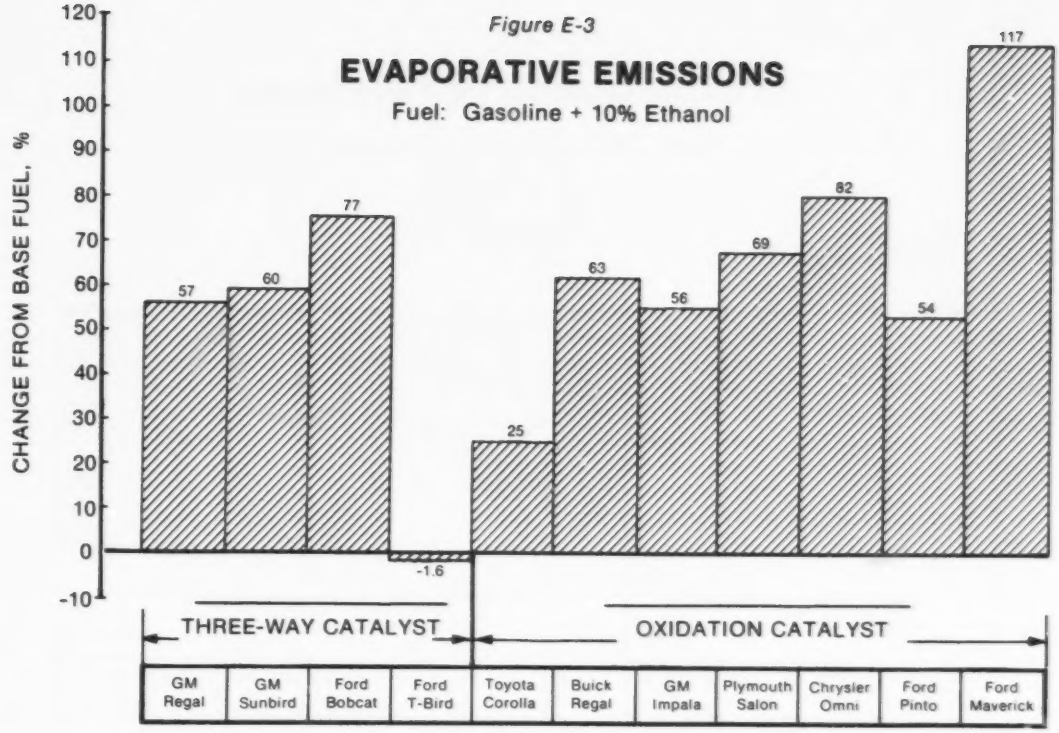


Figure E-4

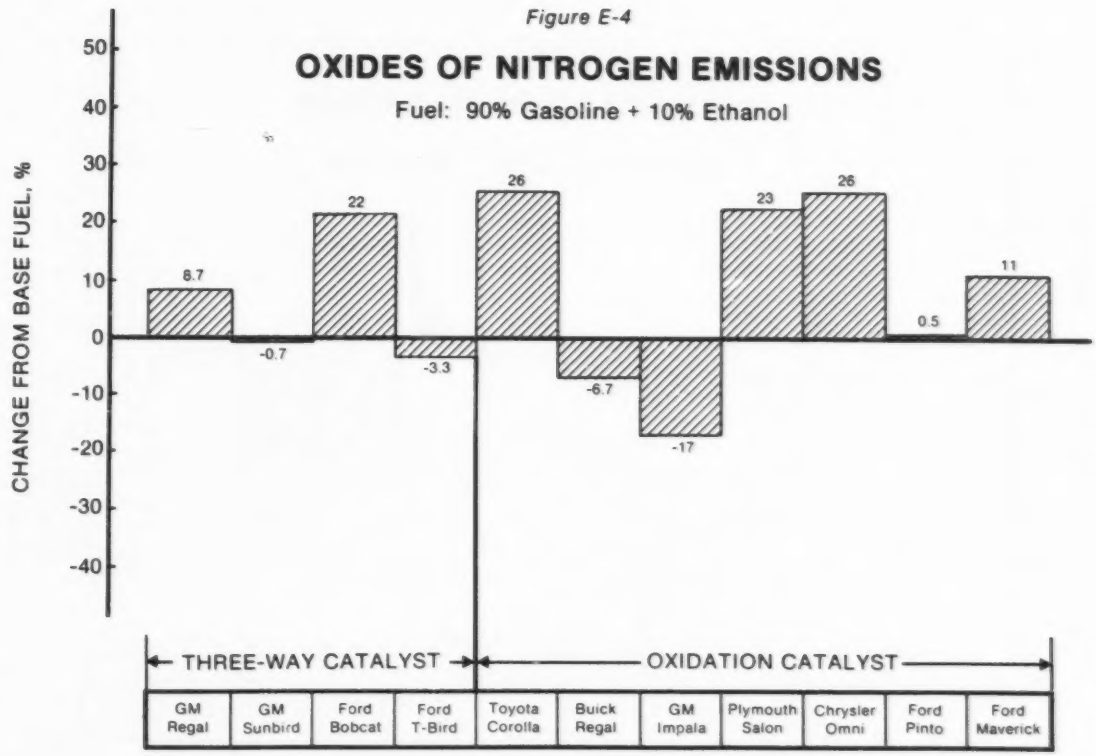


Figure E-5

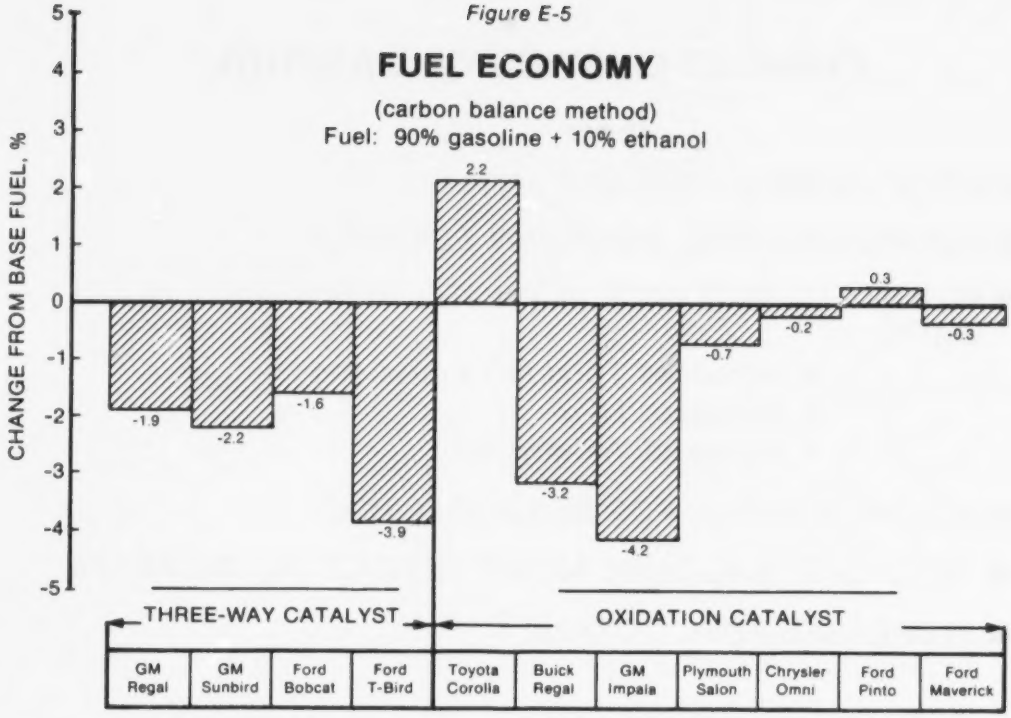
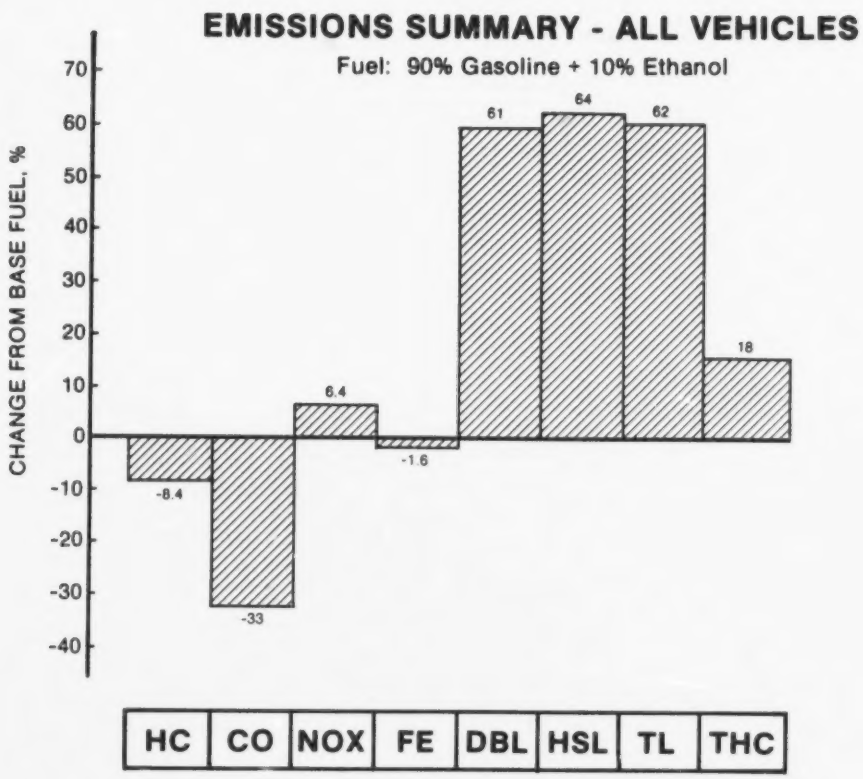


Figure E-6



CHARACTERISTICS OF GASOHOL

Figure E-7

- DECREASES CO SIGNIFICANTLY
- DECREASES FUEL ECONOMY SLIGHTLY
- POTENTIAL INCREASE IN PHOTOCHEMICAL SMOG
  - Increases Total HC Emissions
  - Increases NOx
  - Increases Aldehydes
- ADVANTAGEOUS FOR SEASONAL USE
- "BLENDED" GASOHOL MIGHT REDUCE HC INCREASE
- INCREASES FUEL OCTANE

POTENTIAL HEALTH PROBLEMS WITH FARM ENERGY

by
David L. Coffin, Health Effects Research Laboratory
Research Triangle Park, North Carolina

The idea of using alcohol for fuel appeals to me possibly because I am a winemaker and come from the Southeastern states which are said to constitute the moonshine belt.

Incidentally, I read in the Wall Street Journal the other day that a farmer in Minnesota constructed a workable apparatus for the production of alcohol at a cost of $15,000. Possibly his success and low cost may be attributed to the fact that he had an ex-Alabaman moonshiner for a consultant.

I agree, however, with the previous speaker that moonshining is a dying art. The cost of fuel and sugar make it currently unprofitable. Seriously, there has been much talk of making alternate fuels for a number of years, but the idea of using alcohol as a fuel in itself, or as a gasoline extender, has caught the popular fancy probably because it is the one fuel now being considered which can be made at the grassroots with materials readily at hand and with quite low capital expenditure. This is certainly not the case with shale oil or fluidized coal which are terribly complex, capital intensive and far beyond the scope of all but the greatest industries.

The subject of this conference is gasohol and the possible role of the individual farmer in producing his own fuel from grain or other materials present on his farm. The appeal here is that it would make him independent of the unpredictable shortages of fuel at harvest or planting time, and utilize his surplus or damaged grain for this purpose. Furthermore, it appeals to him as something which he can accomplish himself without governmental handouts.

The potential toxicity of the production of alcohol for fuel and its blending to gasohol should be considered at once so that any pitfalls which may be present can be obviated without delay. The potential points to be considered are as follows:

There is potential toxicity to cattle or other livestock from feeding residues from fermentation and distilling. Here should be considered such factors as fungal toxins from spoiled grain or from herbicide or pesticide residues. It would appear that most of the facts are known, and a literature and feasibility study of these problems by individual contractors can be made economically. If health problems are found to be associated with the waste from on-the-farm alcohol production, it is possible that an alternate route of handling the waste is feasible, perhaps by means of anaerobic fermentation to methane and its use as a fuel for the stills.

·e is a potential problem with combustion products.

While little or no toxicity should arise from the combustion of pure ethanol, its addition to gasoline may lend new combustion problems not due to the alcohol itself, but to its enhancement of pollutants in effluents derived directly from gasoline or altered gasoline combustion products. A previous speaker has indicated that preliminary data from EPA, Ann Arbor, shows increased total Hydrocarbon emissions due to direct gasohol evaporative losses. This is apparently brought about by the alcohol altering the vapor pressure of the fuel. According to the same speaker, Ann Arbor combustion data also indicated an increase in the tailpipe emissions of nitrogen oxides. These observations may have considerable toxicologic import since it is well known that hydrocarbons and nitric oxide are the essential chemical precursors of photochemical smog.

In the gasohol case, we must determine why these perturbations of gasoline effluents are present; and will they contribute to an overall deterioration of air quality to the extent that gasohol-powered cars exceed gasoline-powered cars in this respect. In order to incriminate the hydrocarbon emitted from a gasohol-powered vehicle, it will be necessary to specifically analyze chemically.

Additionally, the diluted exhaust should be subjected to light irradiation and studied for oxidant formation and characteristic photochemical plant damage. If these steps show oxidant formation, it will be necessary to perform animal exposures. The reported increased nitrogen oxide is somewhat of a poser. According to the molecular structure of alcohol, it should combust at a lower temperature and thus emit lower nitrogen oxide. However, it is possible that an air/fuel ratio set for gasoline combustion is sufficiently lean for gasohol so that increased nitrogen oxide would result from incorrect air/fuel mixture.

There is a potential health problem with polynuclear hydrocarbons. At this time, we do not know what effect the admixture of ethyl alcohol will have on the tailpipe emissions of potentially carcinogenic or mutagenic compounds which might either be augmented or diminished in gasohol combustion.

There is a direct toxicity of gasohol fumes to man. It has been pointed out that the addition of alcohol enhances evaporative losses from gasoline. If such were significantly increased from tanks, filling stations and especially alcohol/gasoline blending facilities, there is a possibility workers in proximity to these operations might receive enough exposure to low molecular weight volatile compounds present in gasoline to experience symptoms of dizziness, nausea, and the like when on the job. These factors should receive attention

particularly in the face of the fact that benzene, an acute toxicant already present in gasoline and suspect of being associated with leukemia in low-and long-term contact, may be added to alcohol as a dehydrating agent.

Toxicological studies are recommended on gasohol utilization of brewers and distillery yeasts as stock feed. Agriculture colleges and veterinary schools should be contracted to study the following:

a. Possible toxicity due to mycotoxins or herbicide or insecticide residue in stillage fed to livestock.

b. Advisability of feeding wastes wet or expending energy to dry them.

c. Initiate an engineering study to determine the energy economics of feeding wastes to livestock versus utilizing the waste for fuel to operate a still, i.e., through the anaerobic production of methane.

Gasohol may possibly contribute to photochemical smog. Repeated engineering studies should be made on emissions, particularly reactive hydrocarbon and nitrogen oxide for gasohol (10% alcohol, 90% gasoline). If these prove to be still elevated, proceed as follows:

Set up engine dynamometer studies as indicated below utilizing most efficient carburetor or fuel injection adjustments for each. Vary concentration of alcohol and gasoline approximately as follows:

Alcohol	Gasoline
0%	100%
10%	90%
30%	70%
50%	50%
70%	30%
100%	0%

Chemical comparisons should be made of evaporative losses, hydrocarbon profile, NO_x emissions and other pollutants from each set. if, as expected, chemical parameters differ, the emissions should be diluted and irradiated in a photochemical smog setup.

Irradiated emissions should be examined for smog parameters including oxidant, nitric oxide, nitrogen oxide and peracyl nitrate. Sensitive plants ought to be exposed to irradiated exhaust and examined for characteristic smog lesions. If the above studies indicate toxicity, experimental animals should be exposed in an infectivity system. All results with gasohol combustion emissions should be compared with straight gasoline combustion emissions.

Gasohol combustions may possibly contribute to mutagenic or carcinogenic exhaust content. Particulate and vapor phase effluent should be collected from both irradiated and nonirriated cooled exhaust. Sentinel carcinogenic compounds should be monitored chemically, and examined by the Ames Test for biological evidence of mutagenesis.

There is no question concerning the feasibility of the combustion of alcohol as a fuel for motor vehicles. It would appear that alcohol production is economically feasible at present fuel prices and that it can, if widely adopted, result in a considerable savings in imported petroleums. Feed stocks for the production of alcohol are ubiquitous. These include not only the use of grain, as in the subject of this conference, but agricultural wastes such as straw, corn stalks, forest waste, and crops especially grown for this purpose.

While it is immediately practical to use ethyl alcohol as a gasoline extender, as in the 1 to 10 ratio for gasohol, it may well be that, in light of the possibilities of alcohol/gasoline interaction to form toxic products, it might be a good idea to consider other mixtures, possibly some mixture of alcohol or gasoline, may very well not only produce a savings of exported petroleum, but tend to reduce toxic products from automobile emissions. The plan presented above should develop information on which to base such decisions.

Studies should be undertaken to accomplish the following:

a. Insure maximum effective use of waste products for stock feed.

b. Determine the least polluting mixture of alcohol/gasoline which is feasible for use in present and future internal combustion engines.

c. Check possible toxicity for gasohol handlers at blending stations and service stations to determine safety regulations if required.

The use of alcohol as a substitute fuel should be of great interest to EPA for the following reasons: Alcohol can be made from renewable resources, much of which are being wasted today. Compared to shale oil or coal extraction, its production is relatively nonpolluting. The technology is fully developed and can be applied quickly to the fuel problem. Finally, most important to our Agency, it provides hope for a cleaner fuel than gasoline for automobile use. In order to realize this potential, an integrated engineering and health effects program such as outlined above needs to be implemented, so that we not only can achieve a viable substitute for petroleum, but a net gain in our vehicular pollution problems.

I think that is about all that I have to say. I would like to entertain any questions.

Mr. Ortman: Dr. Coffin, I do not think there is anyone that is here who would dispute that aldehydes ar increased. Would you address the issue of the toxici

aldehydes?

Dr. Coffin: Yes. Aldehydes could be a pollution factor, depending upon their concentration. I do not know what levels of aldehydes have been observed.

Dr. Scheller: Published data on the increase of aldehydes from gasohol compared to the unleaded gasoline show aldehyde levels to be very small.

Mr. Allsup: I find that to be the general opinion. The work we have done suggests that aldehydes are destroyed by the catalysts used in the combustion of exhaust hydrocarbons.

Dr. Scheller: I have another comment I would like to make on this concern about air pollution. I think one thing that we have to remember is that our gasoline market is based on a certain number of miles a car is driven each year. We should not get into the controversy of whether gasohol gets more or less miles per gallon; for the sake of this discussion we will just assume that it gets the same miles per gallon. Then the refineries in this country will refine 10 percent less gasoline. I do not know if you have any opinions on what this will do to the quantity of crude oil needed, but we will produce 10 percent less gasoline, which could mean that the refineries will be putting fewer pollutants into the air. I think we need to consider the total impact the use of gasohol will have on the environment. We need to see whether producing alcohol and adding that to gasoline does or does not have an overall net beneficial effect on the environment. We should not just be concentrating specifically on the tailpipe of the automobile. We should look at the total environmental impact.

ENERGY AND ECONOMICS OF GASOHOL PRODUCTION

by
Robert Mournighan, EPA Industrial Environmental Research Laboratory, Cincinnati, Ohio

I think this is going to wind-up as being more of a summary than anything else, because of the information that has been developed here so far.

I see a major environmental issue that is associated with on-the-farm alcohol production, and Dave Coffin has brought up a number of other issues such as, burning the crop waste and coal as fuel. This all is assuming that we get away from using liquid fossil fuel to provide the energy to make the ethanol from grain for gasohol. So, we have a problem of widespread use of coal as the process steam.

We would have to develop controls for hydrocarbon emissions, wastewater treatment and also for the fugitive emissions if we are going to use the distillation process for making alcohol.

We also have the typical wastewater problems associated with beverage alcohol plants. We have the solid waste from the boiler and ash from the precipitators. Possibly from the use of high sulphur coal, we may have an sulfur dioxide problem. We have wastewater plant sludges and process waste, depending on the kind of waste treatment process in use.

The automotive emissions seem to be in debate. The question is whether or not we have lower automotive emissions; as far as carbon monoxide is concerned, yes we do.

Taking the beverage alcohol as the base for making 200 proof, I would like to go over some process development goals where we could reduce the amount of energy needed to produce the alcohol. We would have to use the lower energy processes in the feed stock. The energy feed stock would have to be something other than fossil fuel. But to get to the replacement of 100 or so billion gallons a year of gasoline by gasohol, we would need an increase in alcohol fermentation capacity to 35 million gallons per day. This represents about 500 plants producing 70,000 gallons of alcohol per day. We estimate that the capital required for this would be eight to ten million dollars, depending on how fast we are able to go.

The increased capacity through the next five years would probably require five billion dollars more. We need to assess the economic environmental impact to make sure we are going in the right direction and we need the continuing Federal and State commitment to keep us on the right track. We have the four cents a gallon Federal tax taken off gasohol, so that is a step in the right direction, at least to set up the gasohol industry.

first slide (Figure G-1) is a block diagram. You have his before. It was shown in the Radian presentation. It shows the collection of the feed stock and hydrolysis processes. The fermentation step requires cooling. Distillation, purification, dehydration and blending of gasoline requires a large amount of energy. The main thing that concerns us here is the ability to reduce the amount of energy to produce the ethanol.

This was just a suggested scheme to do just that; mash from fermentation could be fed to a freeze concentrate (Figure G-2). The solids from the process could go to produce methane, a fuel for the process heat which would go into the extraction step of alcohol with gasoline, removing the alcohol from the water that is left after distillation; if further dehydration is needed, it is possible to distill the mixture, strip the water out of the gasoline and alcohol, and obtain a 10 percent gasohol product.

We have sort of a laundry list of things that can be done to reduce the cost of producing ethyl alcohol. These include: vacuum distillation (Figure G-3), lowering the temperature of the feed stock and conversion processes, the use of freeze concentration and extraction. These steps would eliminate distillation. The use of gasoline rather than benzene in the dehydration step is a possibility. As stated before, benzene is a very toxic compound and should be eliminated in the dehydration process. It is possible to eliminate the dehydration step and use the 190 proof alcohol as the summer blend with gasoline.

Drying solids accounts for 50 percent of the energy inputed into the process. If we turn around and make it into an energy producer, we are heading in the right direction. If it is competitive with gasoline we are headed in the right direction.

Does gasohol improve engine performance (Figure G-4)? Some say yes, some say no. The Nebraska two million mile test indicated, I believe, a 3-6 percent increase in mileage with a five percent increase on the average.

Mr. Lawrence: There is an increase in mileage in the Nebraska two million mile test but not in performance.

Mr. Mournighan: Right.

Mr. Lawrence: Granted, gasohol increases octane in the fuel and also improves the car's performance.

Mr. Mournighan: We need to know what the environmental problems are. Some of these problems are shown in this slide (Figure G-5). What is the current commercial status? I touched on that. What are the steps needed to gain wide acceptance? The main thing is to

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show that gasohol is a good quality fuel. The next slide (Figure G-6) gives a comparison based on the wholesale price of gasoline and the current cost of ethanol at 200 proof at $1.40 a gallon, and 190 proof at $1.30 a gallon. This is taking into account the removal of the four cent excise tax on gasoline-alcohol blend. The current price of gasoline on the wholesale market becomes 52 cents a gallon; adding the 13 cent tax, brings the total to 65 cents.

The higher octane content of the ethanol reduces the octane requirements of the gasoline used for blending. A penny per gallon can be saved when a lower octane gasoline is used for blending. Using 200 proof alcohol in blending, there is a contribution of 45.9 cents from gasoline (90 percent of 51), 14 cents from the alcohol portion and 9 cents for the tax. The state tax is an average nationwide. When 190 proof is used for blending the price is 67.9 cents versus 65 cents for regular gasoline.

Making the comparison on wholesale price eliminates all the variables that are inevitable when including transportation, marketing and retailing. I think it shows that if OPEC is going to cause another four cent to six cent rise in gasoline, it will take about $1.00 a gallon on the wholesale level before gasoline prices will be equal to the market price of gasohol.

Mr. Berg: How about the quantity? Gasohol looks competitive and everything, but what percent can we really expect to see in the marketplace, let's say by 1985, by 1990? Even if OPEC prices go up, we still can't produce the quantity of alcohol needed over the next few years.

Mr. Mournighan: I think that is why the Federal and State governments are offering assistance.

Dr. Scheller: If we are to take the grain which is not being produced on the set-aside acreage, there would be sufficient grain to produce two and one-half (2.5) billion gallons of ethanol, which could make 25 billion gallons of gasohol.

Mr. Lawrence: Two and one-half billion gallons of ethanol is roughly two percent of our energy requirements.

Dr. Scheller: I don't care what percent of the energy it is, in grain producing areas of the nation, it would let us produce two and a half million gallons of ethanol, which would be 25 million gallons of gasoline consumption. So we have the potential, just from the set-aside acreages, of converting 25 percent of our fuel needs into gasohol, if we had the ethanol plants on line to produce the alcohol. Now to look at utilizing some of the surplus crops such as sugar and other starch crops and bring them into the picture, there is created a current total of about four billion gallons of ethanol which could conceivably be produced in this country without invading the food and feed markets. Four percent of our gasoline consumption can be obtained by converting 40 percent of our fuel requirements to gasohol. Since 1971 Nebraska has always considered the gasohol program as a regional program for the starch and sugar crops produced in the various farm areas of this nation. I don't expect to see many alcohol crops raised in Nevada. I do expect to see alcohol crops raised in Plattsville, Nebraska, Iowa and Louisiana.

Mr. Lawrence: How fast could we build 500 plants?

Dr. Scheller: I think we should be moving very rapidly in building plants capable of producing 50 million or a 100 million gallons per year of ethanol, which means we would need somewhere under 100 plants of this large size capacity.

Mr. Mournighan: Well, the reason that I mentioned 70,000 gallons a day was that this size plant would be adequate for regional locations, and we need about 500 of these plants.

Mr. Lawrence: Well, how long does it take to build a plant? If this country puts its mind to it, could we build 500 plants in two years, five years?

Mr. Mournighan: Well, it takes 12 to 18 months to build a plant.

Dr. Scheller: Yes. Bowling Brothers of America claim they can build a plant from scratch in 18 months.

Mr. Lawrence: Can they build ten plants in 18 months?

Dr. Scheller: Well, this is the question. I do not know how our fabricating shops stand right now, in terms of work loads. The program is certainly going to depend on what the overall capital construction is in the nation.

Mr. Lawrence: It looks like plant construction is a relatively long-term approach, in other words, it will be a few years before we can replace our gasoline consumption with alcohol.

Mr. Mournighan: There is also a lot of process development that has to be done. Gasoline, you know, is 90 percent of gasohol. The ethanol price can change an awful lot, but the relative difference in price between gasohol and gasoline is not going to change appreciably. The real critical factor is the price of the alcohol. If the price can be reduced by 10 cents a gallon, that would be a big help.

Dr. Scheller: Well, in a 100 million gallon a year plant, of course there is some economics of large scale. Please do not confuse the market price of $1.09 per gallon of fuel grade ethanol with the cost of production.

Mr. Mournighan: Exactly.

Dr. Scheller: This is all the market will bear. Their production costs are way down.

Mr. Mournighan: That is just $1.40 or $1.30 straight alcohol, wholesale price.

Dr. Scheller: Incidentally, in that 190 column (Figure G-6) you do not have 10 percent alcohol. You have 9.5 percent alcohol and 0.52 percent water.

Mr. Mournighan: Right.

Mr. Berg: I was wondering where do you think we are going to get this 30 to 40 cents per gallon production cost which comes out to about 25 percent cost savings? Where are the engineering opportunities for that?

Mr. Mournighan: That is what I was just outlining. I think by judicious engineering, the price can be brought down by almost 30 cents a gallon.

Mr. Berg: So you think there is a 20 or 25 percent flexibility in the cost of production?

Mr. Mournighan: I have no hard data to back up, but considering energy costs only and not including the cost of the grain, I heard a number quoted as 70 cents a gallon as the wholesale price for ethanol.

Mr. Sheil: I think you are referring to the reduction in energy requirements during production and that you are talking about using some kind of petroleum or coal fuel. What about the refuse derived fuel which costs as high as $50 a ton? Where does that come in, or where will it come in?

Mr. Mournighan: Yes, fuel can be derived from the cellulose.

Mr. Sheil: Well, the cellulose converts to sugar, and can serve in the energy production requirements. Steam can be generated from refuse derived fuels; I saw nothing about that in your presentation. I am certain you can get a tremendous amount of trade-off using refuse fuels though there would not be a reduction in energy requirements.

Mr. Mournighan: We do not want to use fossil fuels.

Mr. Sheil: The use of fossil fuels can be avoided and a refuse derived fuel can be a spinoff from solid waste management.

Dr. Scheller: There is something else we should not forget in this cost analysis which is the fact that gasoline is already subsidized to the consumer. The exact figures may be debated by some people who may feel it is as much as 20 cents per gallons. Again, I say to the consumer, not necessarily to the oil company, it is not fair to expect that alcohol should compete without subsidy in a fuel system that is already subsidized. So, I think we should include in the cost some subsidy for the alcohol as being their fair share of subsidy. Furthermore, there could be a re-allocation of subsidies in the set-aside program for this year which is costing 1.6 billion dollars. If this sum had been given as an alcohol subsidy to permit the farmer to produce full tilt, that would have been 64 cents a gallon, or two and one-half billion gallons of alcohol production. That would have done a lot for the economics.

Mr. Mournighan: Yes. My main point in showing this is that it is the worst case.

Dr. Scheller: I agree.

Mr. Mournighan: It is the worst case, and it looks pretty good.

Dr. Scheller: Yes.

Mr. Mournighan: I think with the right steps it will be more competitive.

Dr. Scheller: I agree with you.

Mr. Lawrence: You said there is 20 cents a gallon of gasoline subsidy somewhere. If I read that correctly, that is four cents a gallon for gasohol, which is 40 cents a gallon on ethanol. So it seems like there is already some subsidy.

Dr. Scheller: Yes. That is right.

Mr. Mournighan: There is a choice of using lower proof alcohol or 200 proof alcohol which amounts to 3.9 cents difference before the cost is added in.

Mr. Struzeski: This is not the cost of actually producing alcohol. This is the cost of alcohol on the market.

Mr. Mournighan: Right. If you were a blender, for example, this is what you would have to pay.

Mr. Struzeski: How firm is the $1.40 per gallon for 200 proof or 190 proof?

Mr. Cawley: That is not projected, but that is the price.

Mr. Struzeski: What would it cost me to set up and produce ethyl alcohol?

Mr. Mournighan: Twenty-nine million dollars for 20 million gallons a year roughly.

Dr. Scheller: Yes. Thirty million dollars for a twenty million gallon per year plant. The conversion costs would probably be around 35 cents per gallon. For a 20 million gallon a year plant, the conversion costs which consist of utilities, labor, maintenance, supervision and overhead, property taxes, insurance and chemicals would run about 35 cents per gallon of anhydrous ethanol. Then the net grain cost, which is the cost of the grain minus the income from the by-product, cattle feed, would be in the order of 40 cents per gallon of alcohol produced. At that point, net grain costs, plus conversion costs, are about 75 cents a gallon. Out of this you have to add any profit, corporation taxes and , depending on how you handle depreciation of capital recovery, you have to put in a line for that. But, there are marketing costs which are relatively small because of selling large volumes to a few customers. So this, depending on all of the assumptions made, amounts to a dollar a gallon of alcohol with a 12 to 14 percent rate of return on the capital investment.

Mr. Struzeski: Does this take into account environmental factors such as waste treatment? As I have seen different sets of cost figures here, that is why I am having difficulty coming back to the $1.40 per gallon. I am wondering if the waste factor has been included in these cost estimates.

Dr. Coffin: I would like to make a few comments, if I may, concerning the costing. I think we get too hung up on the cost. What cost are we talking about? It seems to me the most important thing is the energy balance. What is it going to be if we have to pay that much for gasohol, what is it--we are not getting enough of petroleum so we have to get something else. It seems to me that there are several factors. One is that petroleum is not truly an economic factor; either we have been stealing petroleum for many, many years with very low costs or now we are paying what it is worth and complaining about it. Actually, petroleum is a very valuable commodity when it is in short supply.

We have to have alternate energy sources. This country has got to have fuel to exist as it does now. So where are we going to get it? We want to get it from alcohol, we are going to get it from shale, we are going to get it from coal. Now it is alcohol, I am not saying it is competitive with petroleum, because petroleum is subsidized. It maybe competitive with coal, or it may be competitive with shale. I think it is competitive with these fuels; furthermore, I do not think we should make the mistake in this country again of trying to get one big system that runs everything. We are going to have to have a variety of energy sources.

We are going to have to have alcohol, we are going to have to have oil shale. We are going to have to have coal and God knows what else liquified, if we are going to meet our energy needs. I think that the small matter of balance of dollar bills here or there in the long run is going to be very small. It is not going to be worth arguing about.

Mr. Mournighan: It is like arguing about the mileage, the differences are not worth arguing about.

Dr. Coffin: Yes. Because a dollar spent overseas is more significant to our economy than a dollar spent in America. We must not discount the balance of payments, inflation and all these other factors. So, I think that these are very small matters that we are talking about. We have to get this show on the road with these alternate fuels.

Mr. Thornton: I have heard it claimed that it takes more energy to make ethanol than we can get back out. Is there any truth to that?

Mr. Mournighan: It all depends on where you start. Has anybody done an analysis for gasoline? How much energy does it take to make a gallon of gasoline and is it worth it?

Mr. Thornton: I have no idea.

Mr. Mournighan: I think that is the subject Dr. Scheller has discussed many times, and it is really not fair to start arguing about difference in cost, when as Dr. Coffin says, the point is that we must get away from using the very thing we are trying to avoid using, which is imported liquid fuel as a feed stock to make the ethanol.

We can use alternate energy sources, like refuse derived fuels. If natural gas ever comes in a big supply again, we can use coal. As long as we get away from the very thing we are trying to avoid, which is using imported liquid fuels, we can use alternate energy sources.

Mr. Thornton: The plans for making ethanol on a large scale right now all involve using fuel other than petroleum to provide the energy to make the ethanol.

Dr. Scheller: May I give a very concrete number, a process design, careful process design, including the recovery facilities to optimum level have a fossil fuel energy requirement of 70,000 BTU's per gallon of ethanol produced. The energy content of the ethanol, if it is a fuel grade content of ethanol is about 84,200 BTU's. So alcohol can be made utilizing less energy than the energy obtained from alcohol produced. The fossil fuel content of energy in corn is about 46,000 BTU's per gallon of fuel produced.

The energy content of the distiller's grains and cattle feed by-products, as digestable energy, used by the cattle is about 40,000 BTU's. So the overall net effect on this is that there is a total net energy going over all fossil fuel that is used in making alcohol. This is not the key area, we need an energy balance on the whole system.

We are comparing the energy consumption for a gasoline system with the energy consumption for a gasohol system and right there you start off by replacing one gallon of petroleum with a gallon of alcohol.

Then there is the energy credit, which is obtained when you put all of this together, including octane effects an heat production effects. Remember, when you compare gasoline with gasohol the same amount of heat must be produced in both cases, in order to compare the overall energy balance. There is a saving on the order of one gallon of petroleum for every gallon of alcohol that is substituted for the gallon of gasoline resulting in a net savings of one gallon of gasoline.

Mr. Mournighan: I have seen figures on methanol from coal. Just using the coal input to methanol conversions plant, it takes two BTU's of coal to produce one BTU of methanol fuel. That does not take into account the energy used in gathering and mining the coal, transporting the coal, etc. It seems there is always a loss of energy in transformation.

Mr. Berg: Just one other question, Dr. Scheller. How many BTU's does it take to produce a bushel of corn?

Dr. Scheller: About 46,000 BTU's to produce a bushel of corn and the energy in a bushel of corn is 2.6 tim

46,000 or 120,000 BTU's.

Mr. Berg: So to produce the corn requires 120,000 BTU's. I calculated only 46,000.

Dr. Scheller: No, no, no. I am considering fossil fuel energy, that is, fertilizer, insecticides, herbicides, running all the machinery and everything else. In fact, there is even a little bit of energy included in human labor. It is 120,000 BTU's per bushel. Now to get back to estimating cost, we know that the Farmer's Union National Newsletter had a comparison showing the effect of increased gasoline prices on the cost to the consumer; they had assumed two fuel levels, one a certain number of miles per gallon and the other a certain amount of driving per year. Gasoline prices came out at the first fuel level, $450 a year and at the other fuel level $620 a year -- fuel costs. The difference is $170 per year or 50 cents a day which is not something that is going to make me leave my car in the garage if I want to go somewhere. This is the situation with most people. We are so tied to mobility that we become accustomed to having the automobile and are quite willing to pay for the gasoline. We are willing to pay more for it in the future than we are paying now.

Mr. Dial: We are talking about 500 alcohol plants. The production of alcohol from ethylene which is obtained from oil was in 1977, about 305 million gallons per year.

The ethylene which is a feed stock from oil is what we want to avoid. I was trying to present a case of going to production of alcohol from grain equivalent to the production of ethylene from oil. The present alcohol production is 85 million gallons; we need to replace a 100 billion gallons a year of gasoline with gasohol which is roughly 12 percent of the quantity needed. We would have to increase from 85 to 12,000 -- that ratio.

Dr. Scheller: No, that is 12 billion gallons of gasohol, 1.2 billion gallons of alcohol.

Mr. Dial: To replace the whole market of gasoline, which I believe was also quoted earlier as 100 billion gallons a year, right?

Dr. Scheller: So 10 billion gallons of alcohol would convert the whole gasoline market to gasohol, right?

Mr. Dial: Right. But the production two years ago was only 85 million gallons. We would have to get up to 12 billion gallons per year. That is a large order.

Mr. Mournighan: We look at it from our own little area of interest. We should cooperate with other agencies. Now we have developed programs of environmentally acceptable methods of waste disposal. We have developed programs for the utilization of agricultural wastes in the oil fuel program and in the wasted fuel area and analyzed the socioeconomic effects of gasohol and development on policy of the grain markets.

There is one quote that I remember: "If we went to the to replace the gasoline with gasohol, we would have enough distiller's dry grains to feed ten times the number of cows we have here."

Dr. Scheller: Yes, I know. But you know, people make these statements and they do not throw in the appropriate fiscal handbooks and find out how many head of cattle there are.

Mr. Mournighan: I think in order to make ethanol production self sufficient, we would have to use grain as a source, or grain waste as a source. We could develop a program to use the distillers grains as an energy source, by converting it to methane, as Dr. Coffin suggests.

Dr. Scheller: I have seen so many gasohol reports come out where all the report writer has done is to read the previous report. This is chased around and around and now there is all kinds of misinformation in those reports. If they had just gone back to the basic information sources, rechecked their numbers, they would have found out that in a number of these reports there are figures that resulted from mistakes in copying.

There is an engineering firm that builds alcohol plants; has a long history of building them and has many of them in operation in South America and Europe. They will guarantee a plant that will operate on 74,000 BTU's per gallon of alcohol produced. Furthermore, they will sign a contract saying that if it does not operate at that fuel economy they will take, at their own expense, all steps necessary to bring about that economy. This is a subsidiary of the Austrian government and the financing is by the Austrian government which is behind them. I have seen the detailed heat exchanger, arrangements for the deep recovery facilities in that plant. I have 10 years of experience myself in the oil industry in process design and development. It works. There is no doubt about it. Just prior to 1973 nobody had any economic interest in recovering energy. I think on the other hand, there is one company out in the east which claims to be able to make alcohol at 20,000 BTU's per gallon. That is starting with milled grain. They are claiming this on a corn-based plant doing a milling operation in front of the alcohol plant. They do not count any of the milling energy.

Mr. Scarberry: A purified dextrose is their feed stock from corn.

Mr. Mournighan: So that is misleading to say 20,000 BTU's per gallon. The 74,000 is based on starting with corn grain.

Mr. Scarberry: But then what they are proposing is probably the right way to go about it.

Dr. Scheller: Georgia Pacific does that in the state of Washington. Alcohol is produced from waste derived from the sulphide paper plant.

DEHYDRATED GRAIN ALCOHOL PROCESS

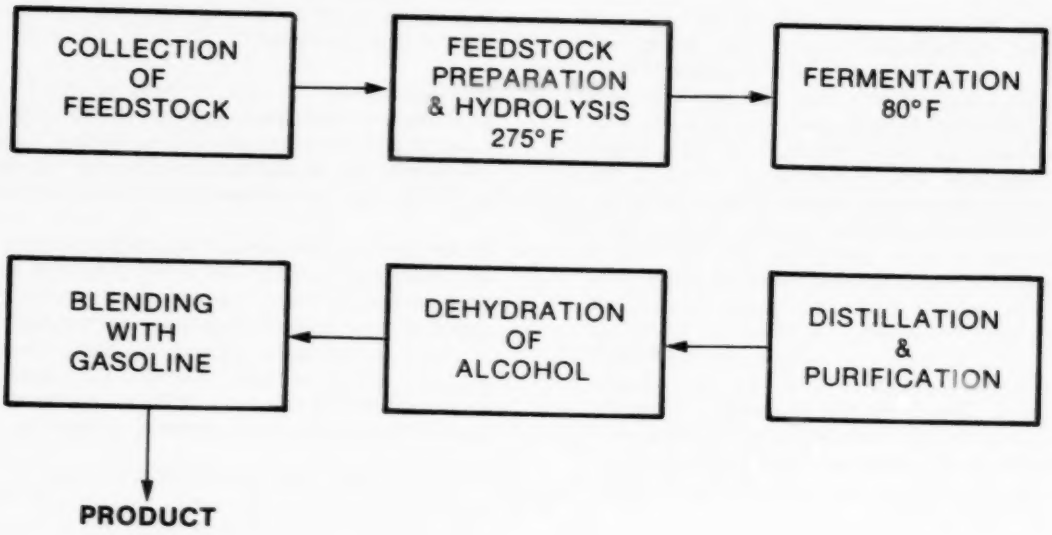


Figure G-1

ALTERNATE GASOHOL PROCESS

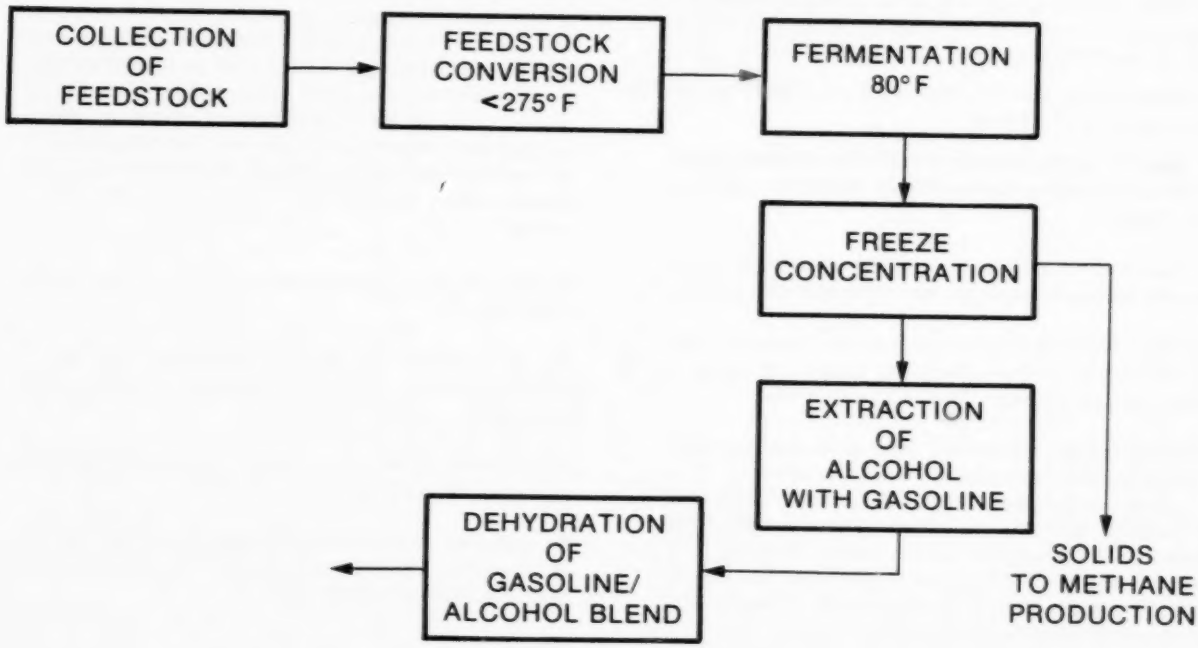


Figure G-2

ETHANOL/GASOHOL

PROCESS ALTERNATIVES

- LOWER TEMPERATURE FEEDSTOCK CONVERSION PROCESS
- VACUUM DISTILLATION OF ETHANOL
- FREEZE CONCENTRATION OF ETHANOL BEFORE DISTILLATION OR EXTRACTION
- EXTRACTION OF ETHANOL FROM WATER USING GASOLINE OR A THIRD SOLVENT
- USE OF GASOLINE (INSTEAD OF BENZENE) IN DEHYDRATION STEP
- ELIMINATE DEHYDRATION STEP
- ELIMINATE REMOVAL OF IMPURITIES (FUSELOIL, KETONES, ALDEHYDES, ETC.)
- ELIMINATE DRYING OF SOLID RESIDUES
- PRODUCE METHANE FROM SOLIDS GENERATED BY THE PROCESS

Figure G-3

GASOHOL PERFORMANCE

- ETHANOL HAS AN "OCTANE" RATING OF 140 COMPARED TO 87-92 FOR GASOLINE
- MILEAGE IS USUALLY 3-6% BETTER
- EMISSIONS ARE REDUCED
- QUICKER, EASIER STARTS, EVEN IN COLD WEATHER

Figure G-4

MAJOR ENVIRONMENTAL ISSUES

- BURNING OF CROP WASTE AS FUEL
- USE OF COAL IN PROVIDING PROCESS HEAT
- VOLATILE HYDROCARBON EMISSIONS FROM WASTEWATER AND FUGITIVE EMISSIONS FROM DISTILLATION
- TYPICAL WASTEWATER PROBLEMS ASSOCIATED WITH BEVERAGE ALCOHOL PLANTS
- SOLID WASTE FROM BOILER AND WASTEWATER PLANT SLUDGE. SOME PROCESS WASTES
- LOWER AUTOMOTIVE EMISSIONS

Figure G-5

JUNE 1979 WHOLESALE PRICE + TAX

	UNLEADED GASOLINE	GASOHOL (200 Proof)	GASOHOL (190 Proof)
GASOLINE	52	45.9*	45.9
ALCOHOL	0	14.0	13.0
TAX	13	9.0	9.0
	65	68.9*	67.9*

*SINCE ETHANOL'S OCTANE RATING IS 140, A CHEAPER CUT OF GASOLINE CAN BE USED (51¢)

Figure G-6

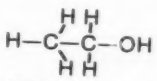
BIOMASS TO ALCOHOL RESEARCH

by
Charles J. Rogers
Municipal Environmental Research Laboratory
Cincinnati, Ohio

Researchers have been seeking for more than 150 years to find economical ways of turning cellulosic wastes into fuels and chemical feedstock to stave off shortages. Many scenarios envision the use of wood chips, old newspapers, municipal sewage and agricultural wastes as sources of inexpensive raw materials. Conceptually, conversion of such materials into energy or into more usable forms of fuel offers the potential for reducing dependence upon foreign sources of energy while helping solve waste disposal problems.

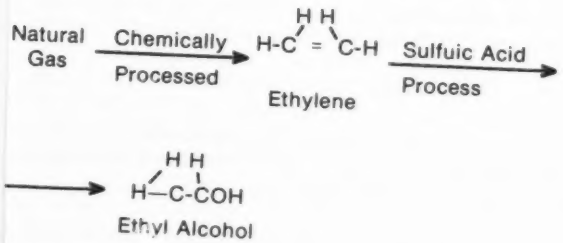
The ORD Municipal Environmental Research Laboratory in Cincinnati has been investigating methods of converting cellulosic waste into alcohol for use with gasoline in the production of gasohol. The most promising approach involves conversion of waste cellulose to glucose by the acid hydrolysis process, followed by conventional glucose fermentation to ethyl alcohol. The results of experiments at the EPA-New York University 1 ton/day acid hydrolysis pilot plant indicate that this approach may be more cost-effective than production fo alcohol from grain or other sources.

Chemically, ethyl alcohol is the common name for the hydroxyl derivative of the hydrocarbon ethane:

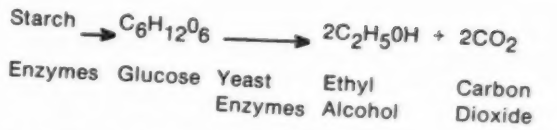


Ethyl Alcohol

Most industrial grade ethyl alcohol produced in the United States is of synthetic origin. The chemical process for industrial grade ethyl alcohol involves production of ethylene by the sulfuric acid process:



Ethyl alcohol used in beverages is produced through fermentation of carbohydrates such as molasses and grain. Starches and molasses are easily converted by enzymes to glucose. Glucose is biologically converted (fermented) by yeast to ethyl alcohol. The glucose conversion is represented in the equation below:



EPA-supported experimental investigations on the dilute acid hydrolysis of waste cellulose to glucose have been conducted at the Department of Applied Science of New York University (NYU) over the past four years. The waste cellulose feedstock employed in these studies was primarily used in newsprint.

Initially, the hydrolysis experiments at NYU were carried out in a 1-liter stirred autoclave equipped with appropriate accessories including electrical heating units and a quick-discharge ball valve removal of the reaction mixture from the autoclave after hydrolysis. The data obtained with the 1-liter stirred autoclave reactor experiments were analyzed to determine the glucose yield at various reaction conditions. This work was followed by additional testing in a 5-liter stirred autoclave reactor.

The batch-scale hydrolysis experiments showed that glucose yields up to 50 percent or more of the available cellulose can be obtained. The optimum reaction conditions were found to be temperatures of around 220°C - 230°C and reaction times of less than 30 seconds, with about 1 wt% of sulfuric acid. These conditions agree rather well with the results of the kinetic rate studies previously reported by Fagan and Porteous.

In the course of the EPA-NYU studies, several pretreatments for the waste newspaper feedstock were investigated in the hope of improving cellulose conversion to glucose. The most effective pretreatment was hydropulping and irradiation. The irradiations were carried out at ambient temperatures and in the presence of air with a 3MeV Dynamitron electron beam accelerator. Irradiation dosages ranging from 5 to 50 megarads were investigated and the 10 megarad dosage was selected as the most cost-effective. The combined costs of this hydropulping/irradiation pretreatment are conservatively estimated at 0.3 - 1.1 cents/lb. waste cellulose feedstock. Figure H-1 shows the significant improvement in the glucose yield obtained by irradiating the hydropulped waste cellulose.

The irradiation treatment was accomplished rather simply. Slurries of hydropulped waste newspapers were placed in polyethylene bags and the bags were heat sealed. Each bag contained about 20 pounds of hydropulped waste newspaper slurry of known cellulose

concentration. The bags were then placed on a conveyor that moved past the beam of the Dynamitron electron beam accelerator. The total dosage per pass was 5 megarads.

The EPA-NYU work includes investigation of continuous processing technology for industrial-scale conversion of waste cellulose to glucose. From this part of the study emerged a continuous waste-cellulose-to-glucose pilot plant with a capacity of one ton per day. This pilot plant will utilize hydropulping, irridiation for pretreating waste cellulose feedstock, and a reactor device for continuously reacting pretreated cellulose in an aqueous slurry at suitably elevated temperatures.

Figure H-2 is a schematic of the Werner & Pfleiderer ZDSK53 (53 mm) twin screw extruder, selected because of its capacity for conveying, mixing and extruding the required amounts of cellulosic feedstock. This machine allows accurate control of temperature, pressure, and residence time and temperature during intensive mixing.

For continuous processing, the extruder must be coupled with a feeding mechanism for cellulose slurries and a discharge system for reacted material, while maintaining pressure and temperature in the reaction zone. A steam-jacketed crammer-feeder made by Werner & Pfleiderer was integrated with the twin screw extruder to maximize throughput with preheating as required. A Kamyr intensive-service 2-inch ball valve (Kamyr Valve Company, Glens Falls, New York) was selected as the major component for the design of the discharge system. Other ancillary equipment includes a high pressure steam generator for supplying energy to the reactor, an acid pump capable of high pressure injection of acid, and a slurry pump for introducing feedstock into the crammer-feeder.

This equipment was installed at NYU's Antonio Ferri Laboratories. Figure H-3 shows a floor plan of the facility which includes space for pulp storage, routine analysis and an office.

The shakedown of this continuous acid hydrolysis system has been completed and optimization studies are continuing. Even though the study has achieved a 50 percent conversion of cellulose to glucose, further experiments are underway to optimize reaction conditions for maximum glucose yields.

In 1978, Kendrick, et al. estimated that ethanol costs about $1.56 a gallon to produce, assuming that one bushel of corn yields 2.6 gallons of ethyl alcohol, and that the cost of producing corn is $2.27 a bushel. The $1.56 includes the cost of transforming a bushel of corn into ethanol and the cost of the distillers' dried grains.

Ethyl alcohol produced chemically from ethylene cost is 15¢ per pound, the cost to produce a gallon of ethyl alcohol is $1.00 (cost of ethylene at 60¢ and conversion expense of 40¢ per gallon. The variable that influences ethyl alcohol production cost is the raw materials. Simply stated, if gasohol is to make economic sense, an alternative low-cost feedstock must be made available for the production of less expensive ethyl alcohol or the cost of traditional petroleum must increase substantially.

Presently, the cost of producing fermentable sugars by acid hydrolysis of waste is estimated at 3 to 4 cents per pound. At least 15 pounds of hydrolysis derived sugar are required to produce one gallon of ethyl alcohol; thus, sugar cost will range from 45¢ to 60¢ per gallon of ethyl alcohol. Including a conversion cost of 40¢ per gallon, the production price of ethyl alcohol would range between 85¢ to $1.00 a gallon.

Because of farmers' production costs, it appears unlikely that ethyl alcohol produced from grain can be cost competitive with gasoline costs at the refinery gate. Ethyl alcohol has proven to be a good extender of gasoline. A national commitment would be required to put in place technology capable of converting 50 percent of available cellulosic waste into fermentable sugars. Experiments are underway to optimize conditions for maximum glucose yields. Concurrently, plans are being developed for cellulose-glucose pilot plants capable of producing 10 to 100 tons per day. This scale-up and coupling of the fermentation process is required to confirm projected costs of 85¢ to $1.00 per gallon for ethyl alcohol derived from cellulosic waste.

Mr. Shell: What is the percent conversion of crop residues to sugars using acid hydrolysis?

Mr. Rogers: The twin screw hydrolysis system is able to convert six percent of the cellulosic feed stock on the first pass. A second pass can convert another 50 percent of the remaining carbohydrates present. It all depends on what will be the cost of another cycle through the unit. That has to be determined. What we have here, in this hydrolysis system, I believe, is a promising method for converting cellulosic materials, including crop residues, into sugars for fermentation to ethyl alcohol. We have investigated a scenario on how this technology should be implemented. We hope to go into a large demonstration program in 1980 employing a mobile twin screw hydrolysis unit. In the scenario the unit should be located in an agricultural area where there is a high density of feed stock. These farm feed stock materials would then be converted into sugar units, high concentrated sugar and possibly transported back to a farm cooperative fermentation center where the sugars can be converted efficiently to alcohol.

Dr. Coffin: Do you see any utility for the residue from this process?

Mr. Rogers: Yes. The residue is sort of a molasses-like material which emerges from the reactor and appears to have the potential for use as a substitute for molasses-type animal feed. We plan on conducting some studies to investigate this possibility.

Dr. Coffin: Is there any fiber left over?

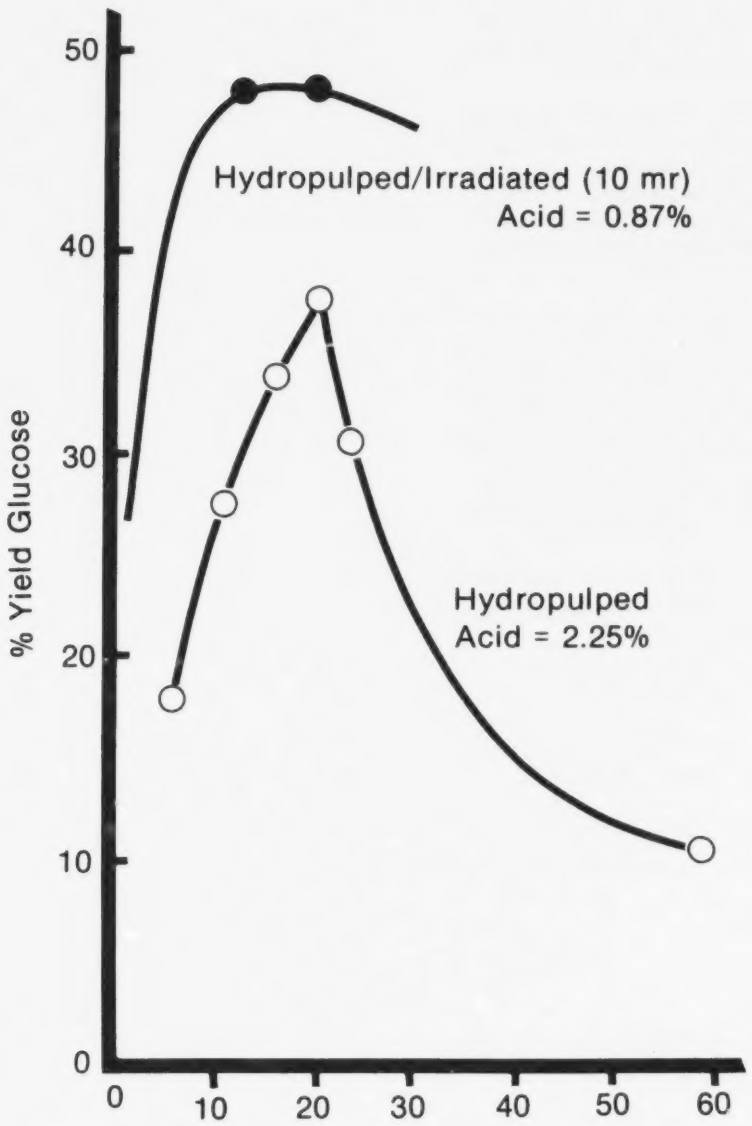
Mr. Rogers: There is some fibrous material remaining after hydrolysis. This fibrous residue may be recycled to produce more sugar.

Dr. Scheller: One of the by-products left over from the acid hydrolysis or enzymatic hydrolysis process is legume. During the war in Germany, actually starting in 1933, the first acid hydrolysis plant was built using Schoeller process, which is high temperature, low concentration sulfuric acid hydrolysis of wood.

Mr. Rogers: The residue can be put into a form known as macroporous, which has the ability to denature certain compounds processed through it. There was a doctoral thesis done in Germany, as I recall, at the University of Munich which appeared in a German pharmaceutical journal which indicated that this microporous material had properties similar to those of antibiotics.

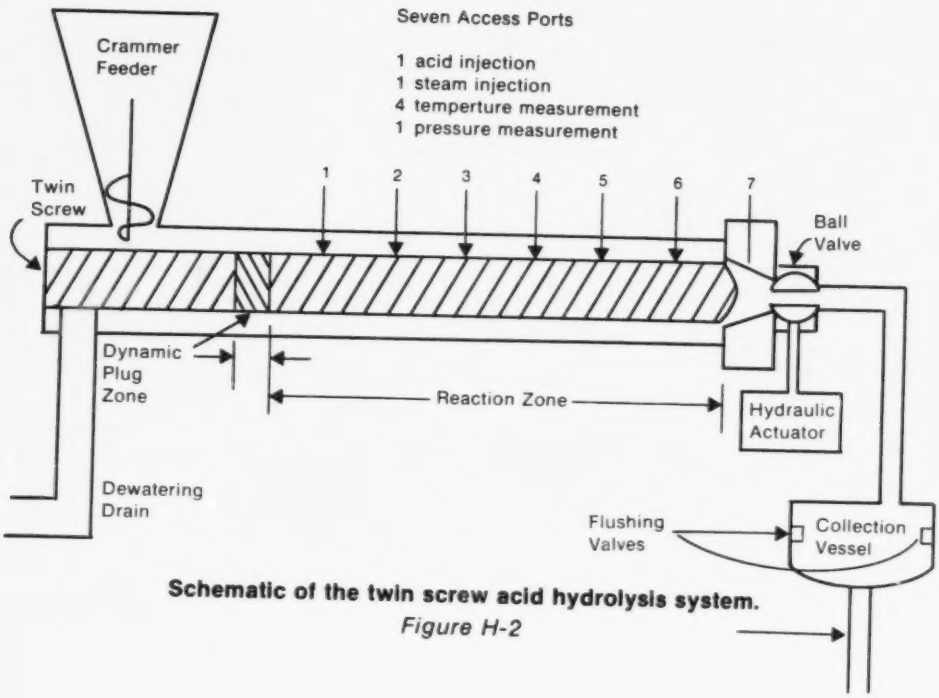
The co-inventor of the Schoeller process, Rudolph Eichelmeyer, lives in Munich and I had an opportunity to spend a few days talking with him about this process, and of course, one of the things he pointed out was that he believes this microporous has properties similar to antibiotics and that this could solve a lot of the problems of using antibiotics in conjunction with meat production if these animals can be given microporous instead. This could reduce a potential hazard to the humans.

I am very interested in promoting a mobile unit acid hydrolysis demonstration program in the agricultural community of Region VII in Fiscal Year 80.



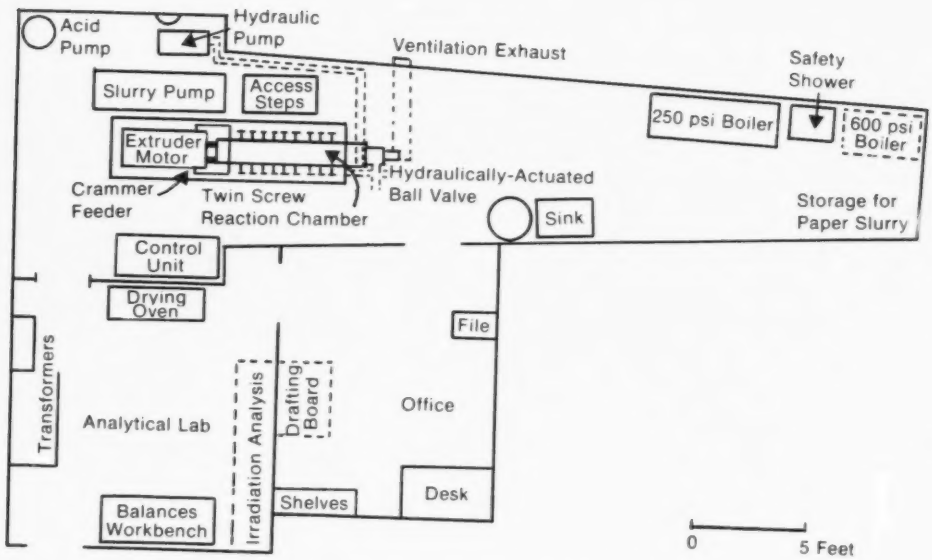
Percent glucose yield vs. reaction time for acid hydrolysis of paper at 450° F.

Figure H-1



Schematic of the twin screw acid hydrolysis system.

Figure H-2



NYU/EPA acid hydrolysis waste cellulose to glucose conversion continuous pilot plant.

Figure H-3

SUMMARY

by

William A. Cawley

I don't think I will make any futile attempts to gather together all of the various thoughts and ideas that were presented today. Rather, I would like to thank everyone for their help.

This has been a very useful and helpful meeting. We seem to be getting more and more of our thoughts together or, at least, sharing them with one another, which is a very productive way to approach this problem. We are moving very rapidly into the area of on-the-farm energy, which is going to require increased activity on the part of our agencies. I suggest that we give serious thought to another meeting of this type in the reasonably near future, possibly on a larger scale, so that we can broaden the inputs. This we hope will result in a coordinated government effort, rather than separate efforts by different agencies.

In closing, I wish to thank you all very much for an excellent meeting.

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